Prevalence and Associated Risk Factors of Human Intestinal Helminths Parasitic Infections in Ethiopia: A Systematic Review and Meta-Analysis

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Background. Intestinal helminth infections are still public health problems in tropical and subtropical countries including Ethiopia. This review and meta-analysis aimed to produce the pooled prevalence and associated risk factors of human intestinal helminth parasitic infections (HIHPIs) in Ethiopia.

Methods. Articles written in English were searched from online databases. Sixty-seven studies were included. Meta-analysis was computed using STATA version 14. Result. The pooled prevalence of HIHPIs was (33.35%, 95% CI: 28.85%, 37.86%). Ascaris lumbricoides (10.84%, 95% CI: 9.34, 12.34), hookworm spp. (8.89%, 95% CI: 7.75, 10.04), Schistosoma mansoni (4.22%, 95% CI: 3.64, 4.81), Trichuris trichiura (2.51%, 95% CI: 2.17, 2.86), Hymenolepis nana (2.29%, 95% CI: 1.96, 2.63), Taenia species (1.01%, 95% CI: 0.80, 1.22), Strongyloides stercoralis (1.17%, 95% CI: 0.92, 1.41), and Enterobius vermicularis (0.71%, 95% CI: 0.52, 0.90) were recorded. Handwashing before food (OR: 5.22, 95% CI: 3.49, 6.94), handwashing after toilet (OR: 3.03, 95% CI: 1.01, 5.05), age (OR: 1.66, 95% CI: 1.09, 2.23), open defecation (OR: 2.42, 95% CI: 1.60, 3.24), eating raw and unwashed vegetables/fruit (OR: 1.98, 95% CI: 1.30, 2.66), maternal education (OR: 1.81, 95% CI: 0.91, 2.72), family income (OR: 2.00, 95% CI: 0.87, 3.31), source of drinking water (OR: 3.12, 95% CI: 1.96, 4.27), swimming/contact with river water (OR: 1.90, 95% CI: 1.11, 2.69), barefoot (OR: 3.28, 95% CI: 1.67, 4.88), playing with soil (OR: 2.64, 95% CI: 1.40, 3.88), and family size (OR: 3.75, 95% CI: 2.03, 5.46) were factors associated with HIHPIs in Ethiopia. High heterogeneity of the prevalence of HIHPIs was observed among the studies within and among regions (I² > 99.6% and P ≤ 0.001).

Conclusion. HIHPIs in Ethiopia were significantly high. Therefore, special attention should be given by all stakeholders to minimize HIHPIs in Ethiopia.

1. Background

Parasitic infections caused by intestinal helminths are among the most prevalent global infections, especially in developing countries [1, 2]. The global annual burden of parasitic infections reaches 3.5 billion. Intestinal parasitic infections (IPIs) account for over 450 million annual morbidities and 200,000 mortalities [3]. Intestinal helminths (IHs) are among such infections that need special emphasis in developing countries [4]. They result in two billion global infections; Ascarisisis (250 million), Schistosomiasis (200 million), hookworm (151 million), and Strongyloides (100 million) [5]. Trichuriasis, another helminth disease, also infects around 800 million people worldwide [6].

The most frequent intestinal helminths in Ethiopia are A. lumbricoides, hookworm spp., S. mansoni, H. nana, T. trichiura, E. vermicularis, S. stercoralis, and Taenia species [7]. Infections with these parasites usually lead to nutritional depletion, poor immunity in infants, mucosal loss and lymphatic leakage, and local hemorrhages [8]. Their associated factors are difficulties in adopting optimal personal hygienic practices, shoe-wearing habit, lack of clean and safe water, high population density, poor waste disposal, non-compliance with health standards, poor postdefecation handwashing, incorrect fingernail trimming, and eating raw meat/vegetables [1, 8–10]. Many studies have been conducted to determine the prevalence and associated risk...
factors of HIHIPs among people in different parts of Ethiopia. However, the prevalence reflected in these small and fragmented studies varied widely and remained inconclusive. Additionally, there is no nationwide study about the prevalence and factors associated with HIHIPs among the people in Ethiopia. Therefore, this review and meta-analysis aimed to determine the pooled prevalence and associated risk factors of HIHIPs among the people of Ethiopia.

2. Methods

2.1. Study Design and Setting. Ethiopia is located in the horn of Africa bounded by North and South Sudan on the west, Somalia and Djibouti on the East, Eritrea on the North and northwest, and Kenya on the South [11]. Ethiopian population is estimated to be 113,869,098. This population is equivalent to 1.47% of the global population. About 21.3% (24,463,423) of the Ethiopian population lives in urban areas. The country’s population has a median age of 19.5 years. The population density of Ethiopia is 115 people km$^{-2}$ (298 people mi$^{-2}$). The total land area is 1,100,000 Km$^2$ [12].

2.2. Search Strategies. We searched articles written in English on international databases such as Pub Med/MEDLINE, Science Direct, Web of Science, and Google Scholar [13]. Literature was collected within the time interval of December 2019-January 2020. The core search terms and phrases used were “prevalence,” “intestinal helminths parasites,” “associated risk factors,” and “Ethiopia”. The search terms were used separately and in combination with the Boolean operators “OR” or “AND”. Finally, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist was used to present and report the results of the study [13].

2.3. Inclusion and Exclusion Criteria. Studies published from 2010 to January 2020 were included. All observational study designs (cross-sectional, case-control, and cohort) reporting the prevalence of intestinal parasitic infections and their associated risk factors among people in Ethiopia were included. Articles that were not accessible, articles written in languages other than English, and articles published before 2010 were excluded.

2.4. Outcomes of the Study. The measurement outcome of this study had two main outcome variables: the prevalence of HIHIPs and factors associated with HIHIPs. HIHIPs are defined as infections caused by one or more human helminth parasites [10].

2.5. Data Extraction. The data extraction protocol was prepared and evaluated by all authors. We extracted information on the name of the author and year of publication, population studied, region and sites of study or focus, total sample size and the number of positives, estimated prevalence, species of intestinal parasites, and potential risk factors associated with individual species of HIHIPs.

2.6. Quality Assessment of Individual Studies Included in the Meta-Analysis. The Grading of Recommendation Assessment Development and Evaluation (GRADE) approach was used to assess the overall quality of evidence [14]. Methodological quality, comparability of the outcome, and statistical analysis of the study were the three major assessment tools that were utilized to declare the quality of the study. Publications with total scores of five to six points were considered as high quality, three to four as moderate quality, and two and below as low quality.

2.7. Risk of Publication Bias across Studies Included in This Meta-Analysis. The risks of publication bias across the studies were assessed using funnel plot symmetry and Egger’s test. The Egger’s test $p$-value $< 0.05$ was used to determine the presence of publication bias across the studies. The cause of publication bias was assessed using a sensitivity test and regression test.

2.8. Data Analysis. The prevalence of HIHIPs was computed by dividing the total number of HIHIP cases by the total number of participants in the studies multiplied by 100. Besides, we used a random-effect model to estimate the pooled effect size (prevalence of HIHIPs). Cochrane Q-test and I$^2$ statistics were used to assess heterogeneity among the studies [15]. To sort out the causes of heterogeneity, we conducted a subgroup analysis based on the region of the study, the nature of study participants, study year, and sample size in individual studies. 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 the prevalence of HIHIPs among respondents. The meta-analysis was conducted using STATA Corp College Station, TX software version 14. $P$-values $< 0.05$ were considered statistically significant.

3. Result

Out of the 321 articles retrieved, 62 articles were excluded due to duplicates, 80 articles due to their titles, and 79 due to their abstracts. The remaining 100 full-text articles were assessed for their eligibility. Twenty-three articles were excluded because of not fulfilling specific inclusion criteria and data extraction protocol. Consequently, 67 studies met the eligibility criteria and were included in the final meta-analysis (Figure 1).

3.1. Characteristics of Original Studies. Among the 67 studies selected, a total of 102, 265 study participants were involved to determine the pooled prevalence of HIHIPs and their associated risk factors among the people of Ethiopia. Among the studies, 85.07% and 14.9% were cross-sectional and retrospective studies, respectively. The sample size of the selected studies ranged from 118 to 2161 (Table 1).
Low prevalence of HIHPIs was reported in studies conducted in Woreta Health Center (2%) [50], Debre Berhan Hospital (3.2%) [71], among food handlers in Chagni town (4.8%) [23], among food handlers in AAU (5.8%) [18], St. Mary Hospital Axum (5.85%) [78], and inmates in Mekelle prison (5.8%) [44]. However, the highest prevalence was reported in a study conducted among street dwellers in Addis Ababa, Ethiopia (87.3%) [28].

Twenty-seven (40.3%) of the studies were from Amhara region, 13 (19.4%) from SNNP region, 15 (22.4%) from Oromia region, 3 (4.5%) from Addis Ababa city, 1 (1.5%) from Harare region, 1 (1.5%) from Benishangul-Gumuz region, and 7 (10.4%) from Tigray region (Table 1). However, no studies were reported from Afar, Dire Dawa, Gambella, and Somali regions.

### 3.2. Prevalence of Intestinal Helminth Parasitic Infections in Ethiopia

The overall national pooled prevalence of intestinal helminth parasitic infections in Ethiopia was 33.35% (95% CI; 28.85, 37.86). High heterogeneity was observed across the included studies ($I^2 = 99.6\%, P \leq 0.001$). As a result, a random-effects model was employed to estimate the pooled prevalence of HIHPIs in Ethiopia (Figure 2).

### 3.3. Subgroup Analysis

High pooled prevalence of HIHPIs was observed from Oromia region (38.45%, 95% CI: 27.04, 49.86), followed by SNNP region (35.58%, 95% CI: 25.80, 45.37), Addis Ababa city (34.45%, 95% CI: -10.99, 79.90), Amhara region (33.84%, 95% CI: 25.85, 41.83), Harare region (26.80%, 95% CI: 21.95, 31.65), and Tigray region (20.38%, 95% CI: 8.95, 31.82) in descending order (Figure 3). But, the lowest prevalence was observed from the Benishangul-Gumuz region (12.70%, 95% CI: 9.30, 16.10). Also, the pooled prevalence of HIHPIs was lower in studies having a sample size of ($n \leq 300$) 24.57% (95% CI: 11.64, 37.49) as compared with those having sample size of ($n > 300$) (35.27%, 95% CI: 30.34, 40.20) (Table 2).

Furthermore, the pooled prevalence of HIHPIs among studies conducted from 2010-2014 was 44.64% (95% CI: 34.39, 54.89) compared with studies conducted from 2015-2019 (29.08%, 95% CI: 24.12, 34.04). Based on the nature of the study subjects, the pooled prevalence of HIHPIs among...
| Region            | Sample size | No. Positive | Prevalence (95% CI) | Quality score |
|-------------------|-------------|--------------|----------------------|--------------|
| Amhara            | 319         | 263          | 81.2 (7.6, 85.3)     | 6            |
| Amhara            | 364         | 73           | 20.1 (16.1, 24.5)    | 6            |
| Amhara            | 410         | 167          | 40.7 (35.9, 45.7)    | 5            |
| Amhara            | 384         | 53           | 13.8 (10.5, 17.7)    | 6            |
| Addis Ababa       | 172         | 10           | 5.8 (2.8, 10.4)      | 6            |
| Amhara            | 401         | 160          | 39.9 (35.1, 44.9)    | 5            |
| Amhara            | 418         | 91           | 21.8 (17.9, 26.4)    | 5            |
| Addis Ababa       | 4977        | 513          | 10.3 (9.5, 11.2)     | 4            |
| Tigray            | 411         | 257          | 62.5 (57.7, 67.2)    | 6            |
| Amhara            | 15455       | 7433         | 48.1 (47.3, 48.9)    | 4            |
| Amhara            | 400         | 19           | 4.8 (2.9, 7.3)       | 6            |
| Amhara            | 304         | 82           | 27 (22.1, 32.3)      | 5            |
| SNNP              | 400         | 296          | 74 (76.8, 84.7)      | 5            |
| Oromia            | 384         | 86           | 21.9 (18.3, 26.9)    | 5            |
| Amhara            | 344         | 250          | 72.7 (67.6, 77.3)    | 5            |
| Addis Ababa       | 355         | 310          | 87.3 (83.4, 90.6)    | 6            |
| Amhara            | 406         | 130          | 32 (27.5, 36.8)      | 6            |
| Amhara            | 384         | 103          | 26.8 (22.5, 31.6)    | 4            |
| Harar             | 340         | 91           | 26.8 (22.1, 31.8)    | 6            |
| Amhara            | 405         | 104          | 25.7 (21.5, 30.2)    | 6            |
| SNNP              | 503         | 364          | 72.3 (68.2, 76.2)    | 5            |
| Amhara            | 4436        | 1768         | 39.9 (38.4, 41.3)    | 6            |
| Amhara            | 783         | 553          | 70.6 (67.3, 73.8)    | 6            |
| Amhara            | 261         | 221          | 84.7 (79.7, 88.8)    | 5            |
| Oromia            | 417         | 41           | 9.8 (7.1, 13.1)      | 6            |
| Tigray            | 21,611      | 1264         | 5.8 (7.1, 13.1)      | 6            |
| Oromia            | 315         | 135          | 42.9 (37.3, 48.5)    | 5            |
| SNNP              | 325         | 46           | 14.2 (10.6, 18.5)    | 5            |
| Tigray            | 384         | 73           | 19 (15.2, 23.3)      | 4            |
| Oromia            | 715         | 435          | 60.8 (57.2, 64.4)    | 5            |
| Oromia            | 561         | 161          | 28.7 (25.3, 32.6)    | 5            |
| SNNP              | 380         | 82           | 21.6 (17.5, 26.1)    | 5            |
| Oromia            | 317         | 53           | 16.7 (12.9, 21.3)    | 6            |
| Tigray            | 291         | 17           | 5.8 (3.4, 9.2)       | 6            |
| Gumuz              | 395         | 50           | 12.7 (9.5, 16.3)     | 4            |
| SNNP              | 213         | 52           | 24 (18.8, 30.8)      | 3            |
| SNNP              | 391         | 157          | 40.2 (29.9, 50.2)    | 5            |
| SNNP              | 351         | 89           | 25.4 (35.3, 45.2)    | 6            |
| Oromia            | 260         | 64           | 24.6 (19.5, 30.3)    | 6            |
| Amhara            | 310         | 6            | 2 (0.7, 4.2)         | 5            |
| SNNP              | 600         | 62           | 10.3 (8.3, 13.5)     | 6            |
| Amhara            | 2338        | 616          | 26.3 (20.4, 29.4)    | 4            |
| Oromia            | 240         | 51           | 21.3 (24.6, 28.2)    | 4            |
| Amhara            | 180         | 40           | 22.2 (16.3, 27.1)    | 5            |
| Amhara            | 133329      | 1750         | 13.1 (16.4, 29.5)    | 5            |
| SNNP              | 388         | 159          | 41 (12.6, 13.7)      | 5            |
| Amhara            | 214         | 66           | 30.8 (36.4, 46.1)    | 5            |
| Tigray            | 442         | 54           | 12.2 (24.7, 37.5)    | 5            |
| Oromia            | 417         | 110          | 26.4 (18.1, 26.4)    | 6            |
| Oromia            | 312         | 211          | 67.6 (62.2, 73.0)    | 9            |
| Amhara            | 2102        | 551          | 26.2 (62.1, 72.8)    | 6            |
| SNNP              | 13679       | 2771         | 20.3 (24.3, 28.1)    | 4            |
| Amhara            | 359         | 174          | 48.5 (19.6, 20.9)    | 5            |
| Oromia            | 118         | 42           | 35.6 (43.2, 53.8)    | 4            |
| SNNP              | 858         | 210          | 24.7 (27.4, 44.9)    | 5            |
| Oromia            | 340         | 226          | 66.5 (36.6, 43.2)    | 4            |
| Amhara            | 365         | 134          | 36.7 (61.2, 71.5)    | 5            |
| SNNP              | 384         | 168          | 43.8 (38.7, 48.9)    | 5            |
| Amhara            | 541         | 418          | 77.3 (73.5, 80.7)    | 5            |
people in Ethiopia was urban dwellers (53.45%, 95% CI: -2.28, 109.19), rural dwellers (51.76%, 95% CI: 38.14, 65.37), under-five children (37.83%, 95% CI: 26.19, 49.47), school children (36.33%, 95% CI: 28.51, 44.15), pregnant women (35.89%, 95% CI: 15.66, 56.12), food handlers (25.14%, 95% CI: 9.34, 12.34), followed by hookworm spp. (10.84%, 95% CI: 9.34, 12.34), and *S. mansoni* species (1.01%, 95% CI: 0.80, 1.22), *T. trichiura* (2.29%, 95% CI: 1.96, 2.63), *E. vermicularis* (0.71%, 95% CI: 0.52, 0.90) among the people of Ethiopia (Table 3).

### 3.4. Common Intestinal Helminth Parasites among People in Ethiopia

The pooled prevalence of *A. lumbricoides* was (10.84%, 95% CI: 9.34, 12.34), followed by hookworm spp. (8.89%, 95% CI: 7.75, 10.04), *S. mansoni* (4.22%, 95% CI: 3.64, 4.81), *T. trichiura* (2.51%, 95% CI: 2.17, 2.86), *H. nana* (2.29%, 95% CI: 1.96, 2.63), *Taenia* species (1.01%, 95% CI: 0.80, 1.22), *S. stercoralis* (1.17%, 95% CI: 0.92, 1.41), and *E. vermicularis* (0.71%, 95% CI: 0.52, 0.90) among the people of Ethiopia (Table 3).

### 3.5. Risk of Publication Bias across the Studies Included in the Meta-Analysis

The funnel plot symmetry proves the presence of publication bias among the studies included in the present meta-analysis (Figure 4). Similarly, Egger’s test results (*P* < 0.05) indicate the presence of a publication bias among the studies.

### 3.6. Factors Associated with HIHPIs among People in Ethiopia

Handwashing habits before food, handwashing after toilet, age, open field defecation, the habit of eating raw and unwashed vegetables/fruits, maternal education, levels of income, source of drinking water, swimming, walking on barefoot, playing with soil, and family size were significantly associated with HIHPIs.

Thirteen studies were used to test the association between HIHPIs and age among people of Ethiopia [5, 7, 8, 10, 21, 26, 29, 48, 50, 57, 60, 67, 77]. The pooled result of this meta-analysis indicated that age is significantly associated with the prevalence of HIHPIs. The odds of having HIHPIs in children up to 14 years was 1.66-fold higher than 14 years and older people (OR: 1.66 (95% CI. 1.09, 2.23) (Figure S1)).

The association between family size and HIHPIs was computed in six studies [7, 10, 40, 48, 64]. People who had a family size above six were 3.28-fold more likely to have HIHPIs than those who had a family size below six (OR: 3.28, 95% CI: 1.40, 3.88) (Figure S11). Uneducated people were 1.81 times more likely to have HIHPIs than those who were educated (OR: 1.81, 95% CI: 0.91, 2.72) (Figure S3). The association between levels of income and HIHPIs was computed in six studies [19, 24, 27, 36, 59, 64]. People who had a low level of income were twice more likely to have HIHPIs than their counterparts (OR: 2.00, 95% CI: 0.87, 3.31) (Figure S4).

There was a significant association between the sources of drinking water and HIHPIs [7, 19, 25, 31, 40, 48, 58, 64, 69, 74]. People who drank untreated water were 3.21-folds more likely to have HIHPIs than those who drank treated water (OR: 3.12, 95% CI: 1.96, 4.27) (Figure S5). The association between handwashing before feeding and HIHPIs was computed from twenty studies [5, 7, 10, 19, 23–31, 45, 53, 59, 60, 64, 65, 69]. The odds of having HIHPIs among people who did not have hand washed habits before feeding was 5.22 times higher than those who had hand washed habits before feeding (OR: 5.22, 95% CI: 3.49, 6.94) (Figure S6).

Similarly, the association between handwashing after defecation with HIHPIs was evaluated using eight studies [7, 19, 26, 36, 41, 48, 53, 60]. The odds of having HIHPIs were 3.03 times higher among people who did not wash their hands after defecation than their counterparts (OR: 3.03, 95%; CI: 1.01, 5.05) (Figure S7). Furthermore, the association between open field defecation and intestinal helminth parasitic infection was computed in this meta-analysis [10, 25, 26, 29, 50, 56, 58, 60, 67, 79]. The odds of having HIHPIs among people who practiced open field defecation was 2.42 more likely to have HIHPIs than those who had not used open field defecation (OR: 2.42, 95% CI: 1.60, 3.24) (Figure S8).

The association between eating raw and unwashed vegetables/fruits with HIHPIs was evaluated in thirteen articles [10, 26, 28, 29, 31, 45–47, 50, 59–61, 79]. The odds of having HIHPIs among people who had the habit of eating raw and unwashed vegetables/fruits were 1.98 times higher than their counterparts (OR: 1.98, 95%; CI: 1.30, 2.66) (Figure S9).

Walking on barefoot was significantly associated with HIHPIs [7, 10, 19, 21, 29, 53, 61, 70]. People who had the habit of walking on barefoot were 3.28-fold more likely to have HIHPIs than their counterparts (OR: 3.28, 95% CI: 1.67, 4.88) (Figure S10). According to the meta-analysis of five studies [26, 50, 56, 57, 70], playing with soil was associated with HIHPIs. People who had the habit of playing with soil were 2.64 more likely to have HIHPIs than their counterparts (OR: 2.64, 95% CI: 1.40, 3.88) (Figure S11).

### Table 1: Continued.

| Region                | Sample size | No. Positive | Prevalence (95% CI) | Quality score |
|-----------------------|-------------|--------------|---------------------|---------------|
| Zemene and Shiferaw [71] | Amhara      | 247          | 8                   | 3.2 (1.4, 6.3) | 5             |
| Teshale et al. [72]   | Tigray      | 410          | 49                  | 12 (9, 15.5)  | 4             |
| Tegegne et al. [73]   | Amhara      | 256          | 36                  | 14.1(18.9)    | 6             |
| Belyhu et al. [74]    | Amhara      | 1813         | 515                 | 28.4 (26.3, 30.5) | 5          |
| Aleka et al. [75]     | Amhara      | 277          | 64                  | 23.1 (18.3, 28.5) | 6          |
| Gebrehiwot et al. [76] | Oromia     | 374          | 240                 | 64.2 (59.1, 69) | 5             |
| Mekonnen et al. [77]  | Oromia      | 1021         | 664                 | 65 (62, 68)   | 4             |

*SNNP: Southern Nations, Nationalities, and Peoples Region.*
The results from the analysis of ten studies [7, 19, 21, 26, 33, 35, 47, 58, 61, 67] showed that swimming in the river was associated with HIHPIs among people in Ethiopia. People who had the habit of swimming in river waters were 1.90 times more likely to have HIHPIs than their counterparts (OR: 1.90, 95% CI: 1.11, 2.69) (Figure S12).

4. Discussion

Human intestinal helminth infections are among the major IPIs in Ethiopia and are the most common causes of morbidity [10]. The overall pooled prevalence of HIHPIs in this meta-analysis was (33.35%) among people in Ethiopia. It
was higher than that of protozoa (25.01%) [80] and the
global prevalence (24%) [81]. The outcome of this meta-
alysis was higher than that of Brazil (10.1%) [82], Thailand
(14.3%) [83], Uganda (26.5%) [84], Cameroon (28.6%) [85],
and Cambodia (26.2%) [86]. However, it was in line with the
study conducted in Tajikistan (32%) [87], and it was lower
than the studies conducted in Lao (41.2%) [88] and Malaysia
(50.4%) [89]. These differences could be due to methodo-
logical, socioeconomic, hygienic, sanitary, weather, climate,
and environmental factors [90].

The prevalence of *A. lumbricoides* (10.84%) in this meta-
alysis was lower than the global prevalence (15.5%) [91]
and higher than the studies conducted in Co te d’Ivoire
(0.8%) [92], Tanzania (6.8%) [93], Cambodia (4.6%) [86],
Brazil (5%) [82], and Western Tajikistan (4.4%) [87]. But, it
was in line with the study conducted in Uganda (9.8%) [84].
However, it was lower than that from Malaysia (24.3%) [89],
Rwanda (28.5%) [94], Cameroon (21.6%) [85], Sri Lanka
(38.4%) [95], and Indonesia (53.5%) [96]. This difference
might be due to differences in the eating habits of raw
vegetables/fruits, environmental conditions [1], and socio-
economy status [97].

The prevalence of hookworm spp. (8.89%) in this meta-
alysis was close to the global prevalence (10.1%) [98] and
higher than the study conducted in Hawassa University
students’ clinic (2%) [63] and Brazil (1.0%) [82]. The out-
come was in line with the study conducted in Bahir Dar,
Ethiopia (6.2%) [7], and Cambodia (9.6%) [86]. However, it
was lower than the study conducted in Uganda (18.5%) [84],
Malaysia (22%) [89], and Indonesia (53.5%) [96]. This
variation might be due to variation practices such as
handwashing, disposal of waste, personal hygiene, and the
wearing of shoes [99].

The prevalence of *S. mansoni* (4.22%) in this meta-
alysis was higher than the global prevalence (3.1%) [100]
and in studies conducted in Ghana (1.7%) [101], Gamo,
Southern Ethiopia (0.12%) [8], and South Africa (0.9%) [102]. However, it was less than in Ethiopia (18.7%) [103].

Figure 3: Regions from where the reports were obtained.
This variation might be due to the difference in the distribution of helminth species in different geographical areas and method differences that might underestimate the detection of helminth infection [54]. Variations in the quality of water, irrigation activities and farming, swimming habits, and water contamination might be the other reasons associated with *S. mansoni* prevalence differences [104].

The prevalence of *T. trichiura* (2.51%) in this meta-analysis was lower than the global prevalence (10.3%) [105] and higher than the study conducted in Uganda (0.5%) [84] and Co te d’Ivoire (1.2%) [92]. However, it was lower than the study conducted in Brazil (4.6%) [82], Malaysia (14.4%) [89], and Indonesia (60.4%) [96]. It might be because of the differences in toilet facilities, handwashing habits, and awareness of the transmission and prevention of helminth infections [66].

The prevalence of *H. nana* (2.29%) in this meta-analysis was lower than the global prevalence (4%) [106] and a study

### Table 2: Pooled prevalence of intestinal parasite among People in Ethiopia, 2020 (n = 67).

| Variable | Characteristic | Number of studies | Sample size | No. of positives | Prevalence (95% CI) | I-squared, p-value |
|----------|----------------|-------------------|-------------|------------------|---------------------|-------------------|
| Region   | Oromia         | 15 (22.4%)        | 6163        | 2611             | 38.45% (27.04, 49.86) | 99%, p ≤ 0.001    |
|          | SNPP           | 13 (19.4%)        | 20283       | 4971             | 35.58% (25.80, 45.37) | 94%, p ≤ 0.001    |
|          | Addis Ababa    | 3 (4.5%)          | 5504        | 833              | 34.45% (−10.99, 79.90) | 99%, p ≤ 0.001    |
|          | Amhara         | 27 (41.2%)        | 45627       | 15195            | 33.84% (25.85, 41.83) | 97%, p ≤ 0.001    |
|          | Harare         | 1 (1.5%)          | 340         | 91               | 26.80% (21.95, 31.65) | 12 =, p =         |
|          | Tigray         | 7 (10.4%)         | 23953       | 1803             | 20.38% (8.95, 31.82)  | 97%, p ≤ 0.001    |
|          | Benishangul-Gumuz | 1 (1.5%)     | 395         | 50               | 12.7% (9.5, 16.4)     | 12 =, p =         |

| Sample size |  |  |  |  |  |  |
|:------------|---|---|---|---|---|---|
| ≤300        | 12 | 2729 | 671 | 24.57% (11.64, 37.49) | 99%, p ≤ 0.001    |
| >300        | 55 | 99536 | 25043 | 35.27% (30.34, 40.20) | 99.6%, p ≤ 0.001  |

### Table 3: Pooled prevalence of some common intestinal helminth parasites among people in Ethiopia.

| Type of intestinal helminths parasite | No. of positivity | Pooled prevalence with 95% CI | I-squared |
|--------------------------------------|-------------------|-------------------------------|-----------|
| *A. lumbricoides*                    | 9273              | 10.84% (9.34, 12.34)          | 99.2%, p ≤ 0.001 |
| Hookworm                             | 8471              | 8.89% (7.75, 10.04)           | 98.9%, p ≤ 0.001 |
| *S. mansoni*                         | 2979              | 4.22% (3.64, 4.81)           | 98.2%, p ≤ 0.001 |
| *T. trichiura*                       | 1887              | 2.51% (2.17, 2.86)           | 96.9%, p ≤ 0.001 |
| *H. nana*                            | 1386              | 2.29% (1.96, 2.63)           | 91.7% p ≤ 0.001 |
| *Taenia* species                     | 619               | 1.01% (0.80, 1.22)           | 91.0%, p ≤ 0.001 |
| *S. stercoralis*                     | 598               | 1.17% (0.92, 1.41)           | 90.8%, p ≤ 0.001 |
| *E. vermicularis*                    | 381               | 0.71% (0.52, 0.90)           | 85.5%, p ≤ 0.001 |
Studies

Estimated Pseudo 95% CI

The prevalence of the Taenia species (1.01%) in the present meta-analysis is close to the global prevalence (0.9%) [109] and is higher than in the study conducted in Cambodia (0.4%) [86]. However, it was lower than the study in South Africa (6.4%) [102]. This difference might be due to the variation in the environment and living conditions of the study participants [26]. Ethiopian people are known for eating raw meat [110].

The prevalence of S. stercoralis (1.17%) in this meta-analysis was higher than in the study conducted in Ghana (0.3%) [101]. However, it was lower than the study outcome of Angola (12.8%) [111] and Alabama (7.3%) [112]. Such variations in the prevalence of helminth infections attribute to variations in water supplies, sanitation, and hygiene [33]. Weakening immunity due to HIV/AIDS among HIV-positive people might also be the other reason for the variation.

The prevalence of E. vermicularis (0.71%) in this meta-analysis was in line with the study conducted in Tepi Town, South West Ethiopia (0.26%) [1, 9]. However, it was lower than the worldwide prevalence (2.3%) and the study conducted in Cambodia (1.1%) [86]. This variation might be due to the differences in the distribution of helminth species in different geographical areas, variations in water supplies, sanitation, hygiene, and methodology used during helminth identification [33, 54]. The habit of sucking fingers/learning materials and playing with soil may be the reasons for enterobiasis infections [113].

The subgroup analysis of this study indicated that the highest prevalence of HIHPIs was observed in Oromia region (38.45%, 95% CI: 27.04, 49.86), followed by SNNPR (35.58, 95% CI: 25.80, 45.37), Amhara region (33.84%, 95% CI: 25.85, 41.83), and Addis Ababa (34.45, 95% CI: 10.99, 79.90). It was similar to the meta-analysis of SNNP (30.39%), Oromia (29.14%), and Amhara (27.55%) regions [114].

Whereas, low prevalence was observed from Harare (26.80%, 95% CI: 21.95, 31.65), Tigray (20.38%, 95% CI: 8.95, 31.82), and Benishangul-Gumuz (12.70%, 95% CI: 9.30, 16.10). The possible justification for this difference might be due to the peculiarities in sociodemographic, environmental, geographical, and behavioral characteristics. HIHPIs prevalence in five of the regions, namely, Oromia (38.45%), SNNPR (35.58%), Addis Ababa (34.45%), Amhara (33.84%), and Harare (26.80%) was higher than the global prevalence (24%) [81]. Prevalence of only the two regions: Tigray (20.38%) and Benishangul-Gumuz (12.70%) had a better prevalence compared to the globe.

The prevalence of HIHPIs in the first five years (2010-2014), 44.64% (95% CI: 34.39, 54.89), was higher than in the second round 2015-2019 (29.08%; 95% CI: 24.12, 34.04). The result showed that the trend of HIHPIs in Ethiopia was reduced. The outcome was similar to a systematic review, and meta-analysis was conducted in Ethiopia in which the pooled prevalence in the years 1997–2002, 2003–2008, 2009–2014, and >2014 was 71%, 42%, 48%, and 42%, respectively [115]. The potential reason for this decreasing rate might be due to the development of awareness about the transmission and prevention mechanisms of HIHPIs and mass deworming programs [116].

The prevalence of HIHPIs was the highest among urban dwellers (53.45%, 95% CI: –2.28, 109.19). It was higher than the report in the study conducted in the Gamo area, Ethiopia (39.9%) [66]. The lowest prevalence of HIHPIs was among patients (17.96%, 95% CI: 14.07, 21.85). It was similar to the study conducted in Shawura, Ethiopia (20.1%) [8]. These differences might come from the differences in diagnostic methods, population density, and geographical and behavioral characteristics.

The odds of having intestinal helminthic parasite infections in children up to the age of 14 years were 1.66 times higher than in adults. It agrees with the study conducted in tropical semiurban communities [117], Ghana [118], and Yemen [119]. Children are vulnerable to infections with HIHPIs because of a lack of well-developed immune systems and playing habits in fecal-contaminated soil [71].

People from large family sizes (greater than six) were 3.75 times more likely to have HIHPIs than those from family sizes less than six. It was similar to that of human intestinal protozoan parasitic infections (HIPPIs) (OR: 3.7, 95% CI: 1.45–5.85) [80]. It agrees with the studies performed in Ethiopia [40] and Ghana [101]. It might be because a large family size increases the chance of contact with each other and may also increase HIHPI transmission. On the other hand, large families could not get adequate medication and treatment.

Uneducated people were 1.81-fold more likely to have HIHPIs than the educated. This finding agreed with the study conducted in Kenya [120], Ghana [101], Bolivian [121], and South Africa [102]. It might be because uneducated people may lack the necessary knowledge and practice towards the transmission/prevention of intestinal helminth parasites.

People with a low-income level were twice likely to have HIHPIs compared to their counterparts. This finding agreed with the studies conducted in Dembiya district, North 
Ethiopia [19], and Haramaya University cafeterias [36]. It might be because low-income people fail to fulfill their sanitary requirements.

The odds of intestinal helminth parasite infections among people drinking untreated water were 3.12 times higher than those who used to drink treated water. It is in line with the studies from Indonesia [96], Uganda [122], and South Africa [102]. It might be because drinking and using untreated water may be a route for human helminth infections [123].

The odds of HIHPI occurrence among people who did not wash their hands before feeding were 5.22 times higher than those who did. This finding agrees with the studies conducted in Indonesia [96], the Eastern Region of Nepal [124], and Indonesia [125]. It might be because unwashed hands contain dust particles and microorganisms that facilitate the transmission of microorganisms fecal-orally.

Likewise, people who did not have handwashing habits after defecation were 3.03 times more likely to be infected with intestinal helminths than those who had handwashing habits. This result was higher than HIPPIs (OR: 2.82, 95% CI: 2.01–3.63) [80]. This finding agreed with the studies conducted in Indonesia [96], Uganda [122], Cameroon [125], and South Africa [102]. It might be because unwashed hands after defecation may contain stool materials and facilitate the transmission of microorganisms fecal-orally.

The odds of HIHPI occurrence were 2.42 times higher among different groups of people with open field defecation habits than their counterparts. It was close to that of human HIPPIs (OR: 2.91, 95% CI: 1.60–4.21) [80]. This finding agrees with a study conducted in Indonesia [96]. It might be because open field defecation would be a source of contamination to food and water sources.

People who had eaten leftover food and raw and unwashed vegetables/fruits were 1.98 times more likely to be infected with intestinal helminth parasites than those who had not. This finding is in line with the study conducted in Sri Lanka [95]. It might be because leftover food and raw and unwashed vegetables/fruits may contain HIPPIs [123].

The odds of having intestinal helminth parasitic infections among people who had the habit of walking barefoot were 3.28 times higher than their counterparts. This finding agrees with studies conducted in Bolivia [121] and South Africa [102]. The reason might be helminths may have easy access into the body through skin penetration.

People who used to play with soil were 2.64 times more likely to be infected with intestinal helminth parasitic infections than those who did not. This finding agrees with the studies conducted in Turkey [126], Bolivia [121], and South Africa [102]. It might be because people who used to play with soil may have contact with soil-transmitted helminths’ eggs, larvae, or adults [127].

Lastly, participants who used to swim in rivers were 1.90 times more likely to acquire HIPPIs than their counterparts. This finding is in line with the studies conducted in Ethiopia in Adi Remets town [21], Bahir Dar town [7], and Jimma town [61]. It might be because river waters may get contaminated with the ova, larvae, or adult helminth parasites.

5. Limitations of the Study
Lack of studies from Dire Dewa, Gambela, Somali, Afar, Harare, and Benishangul-Gumuz regions may underestimate both the pooled and subgroup prevalence of HIHPIs in Ethiopia. Lack of molecular techniques in the studies failed to identify hookworm species.

6. Conclusion
HIHPI prevalence among people in Ethiopia was high and still a major public health concern. The prevalent helminths identified were Ascaris lumbricoides, hookworm, Schistosoma mansoni, Trichuris trichiura, Hymenolepis nana, Taenia species, Strongyloides stercoralis, and Enterobius in descending order. Handwashing before food and after toilet, age, the habit of eating raw and unwashed vegetables/fruits, level of education, levels of income, source of drinking water, playing with soil, walking on barefoot, and family size were significantly associated with HIHPIs.

7. Recommendation
Particular emphasis shall be given to mass treatment and health education. Moreover, studies are needed in Gambella, Afar, Somali, Dire Dewa, Benishangul-Gumuz, and Harare regions.

List of Abbreviations
AAU: Addis Ababa University
AIDS: Acquired immuno deficiency syndrome
CD4: Cluster of differentiation
HAART: Highly active antiretroviral therapy
HIHPIs: Human intestinal helminth parasitic infection
HIHPs: Human intestinal helminth parasites
HIPIs: Human intestinal protozoan parasitic infections
HIV: Human immuno deficiency virus
IPFs: Intestinal parasitic infections
OR: Odds ratio
PRISMA: Preferred reporting items for systematic reviews and meta-analysis checklist
SNNP: Southern nations, nationalities, and people
STH: Soil-transmitted helminths
WHO: World Health Organization.

Data Availability
All related data have been presented within the article and supplementary data. The data set supporting the conclusions of this article is available from the corresponding author upon request.

Ethical Approval
Our study is an investigation of the literature and does not need ethical approval for retrieving the already available public content.
Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors’ Contributions

ML developed the draft proposal under the supervision of DD. Statistical analysis was guided by DT. All authors (ML, DD, and DT) critically reviewed, provided substantive feedback, and contributed to the intellectual content of this paper and made substantial contributions to the conception, conceptualization, and manuscript preparation of this systematic review. All authors read and approved the final manuscript.

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Supplementary Materials

Figure S1. Odds ratio between age and HIHPIs in Ethiopia. Figure S2. Odds ratio between family size and HIHPIs in Ethiopia. Figure S3. Odds ratio between family education level and HIHPIs in Ethiopia. Figure S4. Odds ratio between income level and HIHPIs in Ethiopia. Figure S5. Odds ratio between source of drinking water and HIHPIs in Ethiopia. Figure S6. Odds ratio between no habit of handwashing before feeding and HIHPIs in Ethiopia. Figure S7. Odds ratio between no handwashing after defecation and HIHPIs in Ethiopia. Figure S8. Odds ratio between open-field defecation and HIHPIs in Ethiopia. Figure S9. Odds ratio between eating raw food and HIHPIs in Ethiopia. Figure S10. Odds ratio between walking on barefoot and HIHPIs in Ethiopia. (Supplementary Materials)

References

[1] C. J. Paniker and S. Ghosh, Paniker’s Textbook of Medical Parasitology, JP Medical Ltd, Chennai Tamilnadu, 2017.
[2] A. F. Espinosa Aranzales, K. Radon, G. Froeschl, A. M. Pinzon Rondón, and M. Delius, “Prevalence and risk factors for intestinal parasitic infections in pregnant women residing in three districts of Bogotá, Colombia,” BMC Public Health, vol. 18, 2018.
[3] World Health Organization Strategy Development and Monitoring for Parasitic Diseases and Vector Control Team and United Nations Children’s Fund, Prevention and Control of Schistosomiasis and Soil-Transmitted Helminthiasis World Health Organization/Unicef Joint Statement, World Health Organization, Geneva Switzerland, 2004.
[4] C. J. Paniker, Paniker’s Textbook of Medical Parasitology, Jaypee Brothers Medical Publishers, Daryaganj NewDelhi, 2017.
[5] A. Alemu, A. Atnafu, Z. Addis et al., “Soil transmitted helminths and schistosoma mansoni infections among school children in Zarima town, northwest Ethiopia,” BMC Infectious Diseases, vol. 11, no. 1, p. 189, 2011.
[6] R. Harizanov, I. Rainova, N. Tsvetkova et al., “Prevalence of intestinal parasitic infections among the Bulgarian population over a three year period (2015–2017),” Helminthology, vol. 57, no. 1, pp. 12–18, 2020.
[7] A. A. Fentahun, A. Asrat, A. Bitew, and S. Mulat, ”Intestinal parasitic infections and associated factors among mentally disabled and non-disabled primary school students, Bahir Dar, Amhara regional state, Ethiopia, 2018: a comparative cross-sectional study,” BMC Infectious Diseases, vol. 19, no. 1, p. 549, 2019.
[8] A. Tigabu, S. Taye, M. Aynaalem, and K. Adane, “Prevalence and associated factors of intestinal parasitic infections among patients attending Shahura Health Center, Northwest Ethiopia,” BMC Research Notes, vol. 12, no. 1, p. 333, 2019.
[9] E. Besufikad Belachew, D. B. Tarko, and Y. M. Wallie, “Prevalence of intestinal helminthic parasitic infections and associated risk factors among students in Tepi town, south west Ethiopia,” Science Journal of Public Health, vol. 5, no. 3, p. 192, 2017.
[10] B. E. Feleke and T. H. Jember, “Prevalence of helminthic infections and determinant factors among pregnant women in Mecha district, Northwest Ethiopia: a cross sectional study,” BMC Infectious Diseases, vol. 18, no. 1, p. 373, 2018.
[11] FDRE, About Ethiopia/Geography, Ethiopian Government Portal, Addis Ababa Ethiopia, 2020.
[12] Worldometer, “Ethiopia population,” 2020, https://www.worldometers.info/world-population/ethiopia-population/.
[13] D. Moher, B. Pham, M. L. Lawson, and T. P. Klassen, “The inclusion of reports of randomised trials published in languages other than English in systematic reviews,” Health Technology Assessment, vol. 7, no. 41, pp. 1–90, 2003.
[14] D. Atkins, M. Eccles, S. Flottorp et al., “Systems for grading the quality of evidence and the strength of recommendations: I critical appraisal of existing approaches the GRADE Working Group,” BMC Health Services Research, vol. 4, no. 1, p. 38, 2004.
[15] G. Rücker, G. Schwarzer, J. R. Carpenter, and M. Schumacher, “Undue reliance on I2 in assessing heterogeneity may mislead,” BMC Medical Research Methodology, vol. 8, no. 1, p. 79, 2008.
[16] A. Abate, B. Kibret, E. Bekalu et al., “Cross-sectional study on the prevalence of intestinal parasites and associated risk factors in the prevalence of intestinal parasites and associated risk factors among students in teda health centre, northwest Ethiopia,” ISRN Parasitology, vol. 2013, Article ID 757451, 5 pages, 2013.
[17] A. Derso, E. Nibret, and A. Munshea, “Prevalence of intestinal parasitic infections and associated risk factors among mentally disabled and non-disabled primary school students, Bahir Dar, Amhara regional state, Ethiopia, 2018: a comparative cross-sectional study,” BMC Infectious Diseases, vol. 16, no. 1, p. 530, 2016.
[18] A. Aklilu, D. Kahase, M. Dessalegn et al., “Prevalence of intestinal parasites, salmonella and shigella among apparently health food handlers of Addis Ababa University student’s cafeteria, Addis Ababa, Ethiopia,” BMC Research Notes, vol. 8, no. 1, p. 17, 2015.
[19] A. Alemu, Y. Tegegne, D. Damte, and M. Melku, ”Intestinal parasitic infections and associated risk factors among mentally disabled and non-disabled primary school children in Chuahit, Dembia district, Northwest Ethiopia: prevalence, intensity of infection and associated risk factors,” BMC Public Health, vol. 16, no. 1, p. 422, 2016.
[20] A. Tessema, B. Yitayew, and T. Kebede, “Prevalence of helminthic infections and associated factors among pregnant women attending antenatal care center at Felege Hiwot Referral Hospital, northwest Ethiopia,” BMC Infectious Diseases, vol. 19, no. 1, p. 333, 2019.
[21] A. Gebreyohanns, M. H. Legese, M. Wolde, G. Leta, and G. Tasew, “Prevalence of intestinal parasites versus knowledge, attitude and practices (KAPs) with special emphasis to
Schistosoma mansoni among individuals who have river water contact in Addiremed town, Western Tigray, Ethiopia,” *PLoS One*, vol. 13, no. 9, Article ID e0204259, 2018.

[22] A. W. Nute, T. Endeshaw, A. E. P. Stewart et al., “Prevalence of soil-transmitted helminths and Schistosoma mansoni among a population-based sample of school-age children in Amhara region, Ethiopia,” *Parasites and Vectors*, vol. 11, no. 1, p. 431, 2018.

[23] A. S. Alemu, A. G. Baraki, M. Alemayehu, and M. K. Yenit, “The prevalence of intestinal parasite infection and associated factors among food handlers in eating and drinking establishments in Chagni Town, Northwest Ethiopia,” *BMC Research Notes*, vol. 12, no. 1, p. 302, 2019.

[24] A. Gelaw, B. Anagaw, B. Nigussie et al., “Prevalence of intestinal parasitic infections and risk factors among schoolchildren at the University of Gondar Community School, Northwest Ethiopia: a cross-sectional study,” *BMC Public Health*, vol. 13, no. 1, p. 304, 2013.

[25] A. Abossie and M. Seid, “Assessment of the prevalence of intestinal parasitosis and associated risk factors among primary school children in Chencha town, Southern Ethiopia,” *BMC Public Health*, vol. 14, no. 1, p. 166, 2014.

[26] A. Sisay and B. Lemma, “Assessment on the prevalence and risk factors of gastrointestinal parasites on schoolchildren at Bochera Elementary School, around Lake Zway, Ethiopia,” *BMC Research Notes*, vol. 12, no. 1, p. 410, 2019.

[27] A. Asires, M. Wubie, and A. Retta, “Prevalence and associated factors of intestinal parasitic infections among food handlers at prison, East and West gojam, Ethiopia,” *Advances in Medicine*, vol. 2019, Article ID 2101089, 8 pages, 2019.

[28] B. Mekonnen, “Prevalence of intestinal parasitic infections and related risk factors among street dwellers in Addis Ababa, Ethiopia,” *Journal of Tropical Diseases*, vol. 02, 2014.

[29] B. Sitotaw, H. Mekuriaraw, and D. Damtie, “Prevalence of intestinal parasitic infections and associated risk factors among Jawi primary school children, Jawi town, north-west Ethiopia,” *BMC Infectious Diseases*, vol. 19, no. 1, p. 341, 2019.

[30] B. Abera, F. Biadegelgen, and B. Bezabih, “Prevalence of *Salmonella typhi* and intestinal parasites among food handlers in Bahir Dar Town, Northwest Ethiopia,” *The Ethiopian Journal of Health Development*, vol. 24, no. 1, 2010.

[31] B. Tulu, S. Taye, and E. Amsalu, “Prevalence and its associated risk factors of intestinal parasitic infections among Yadot primary school children of South Eastern Ethiopia: A cross-sectional study,” *BMC Research Notes*, vol. 7, no. 1, p. 848, 2014.

[32] B. Amare, J. Ali, B. Muges et al., “Nutritional status, intestinal parasite infection and allergy among school children in northwest Ethiopia,” *BMC Pediatrics*, vol. 13, no. 1, 2013.

[33] B. Alemayehu, Z. Tomass, F. Wadilo, D. Leja, S. Liang, and B. Erko, “Epidemiology of intestinal helmintiobiasis among school children with emphasis on Schistosoma mansoni infection in Wolaita zone, Southern Ethiopia,” *BMC Public Health*, vol. 17, no. 1, p. 587, 2017.

[34] B. E. Feleke, M. B. Beyene, T. E. Feleke, T. H. Jember, and B. Abera, “Intestinal parasitic infection among household contacts of primary cases a comparative cross-sectional study,” *PLoS One*, vol. 14, no. 10, Article ID e0221190, 2019.

[35] B. Mathewos, A. Alemu, D. Woldeyohannes et al., “Current status of soil transmitted helminths and Schistosoma mansoni infection among children in two primary schools in North Gondar, Northwest Ethiopia: A cross sectional study,” *BMC Research Notes*, vol. 7, no. 1, p. 88, 2014.

[36] D. Marami, K. Hailu, and M. Tolera, “Prevalence and associated factors of intestinal parasitic infections among asymptomatic food handlers working at Haramaya University cafeterias, eastern Ethiopia,” *Annals of Occupational and Environmental Medicine*, vol. 30, no. 1, p. 53, 2018.

[37] D. Feleke, S. Tarko, H. Hadush, D. Gebretsadik, Y. Zenebe, and A. Seid, “Prevalence of intestinal parasitic infections in St. Marry Hospital, Axum, Northern Ethiopia: A retrospective Study Northern Ethiopia: A retrospective study,” 2020, https://www.researchgate.net/publication/338479861 _Prevalence_of_Intestinal_Parasitic_Infections_in_St_Marry_Hospital_Axum_Northern_Ethiopia_A_Retrospective_Study.

[38] D. A. Yesuf, L. T. Abdissa, E. A. Gerbi, and E. K. Tola, “Prevalence of intestinal parasitic infection and associated factors among pregnant women attending antenatal care at public health facilities in Lalo Kile district, Oromia, Western Ethiopia,” *BMC Research Notes*, vol. 12, no. 1, p. 735, 2019.

[39] D. Gedle, G. Kumera, T. Esthete, K. Ketema, H. Adugna, and F. Feyera, “Intestinal parasitic infections and its association with undernutrition and CD4 T cell levels among HIV/AIDS patients on HAART in Butajira, Ethiopia,” *Journal of Health, Population and Nutrition*, vol. 36, no. 1, p. 15, 2017.

[40] E. Kidane, S. Mekonnen, and A. Kebede, “Prevalence of intestinal parasitic infections and their associations with anthropometric measurements of school children in selected primary schools, Wukro town, eastern Tigray, Ethiopia,” *Scientific Journal of Zoology*, vol. 2, 2014.

[41] E. Tefera, T. Belay, S. K. Mekonnen, A. Zeynudin, and T. Belachew, “Prevalence and intensity of soil transmitted helminths among school children of Mendera Elementary School, Jimma, Southwest Ethiopia,” *The Pan African medical journal*, vol. 27, p. 88, 2017.

[42] E. Gadisa and K. Jote, “Prevalence and factors associated with intestinal parasitic infection among under-five children in and around Haro Dimal Town, Bale Zone, Ethiopia,” *BMC Pediatrics*, vol. 19, no. 1, p. 385, 2019.

[43] F. Samuel, A. Demsew, Y. Alem, and Y. Haileslissie, “Soil transmitted Helminthiasis and associated risk factors among elementary school children in ambo town, western Ethiopia,” *BMC Public Health*, vol. 17, no. 1, p. 791, 2017.

[44] F. Mardu, M. Yohannes, and D. Tadesse, “Prevalence of intestinal parasites and associated risk factors among inmates of Mekelle prison, Tigrai Region, Northern Ethiopia, 2017,” *BMC Infectious Diseases*, vol. 19, no. 1, p. 406, 2019.

[45] G. Gebretsadik, “Prevalence of intestinal parasites and associated risk factors among schoolchildren of homesa district (woreda) in Benishangul-Gumuz regional state, western Ethiopia,” *Journal of Family Medicine and Health Care*, vol. 2, no. 4, p. 57, 2016.

[46] G. Alemu and M. Mama, “Intestinal helmint co-infection and associated factors among tuberculosis patients in Arba Minch, Ethiopia,” *BMC Infectious Diseases*, vol. 17, no. 1, p. 68, 2017.

[47] G. Alemu, Z. Aschalew, and E. Zerihun, “Burden of intestinal helminths and associated factors three years after initiation of mass drug administration in Arbamichi Zuria district, southern Ethiopia,” *BMC Infectious Diseases*, vol. 18, no. 1, p. 435, 2018.

[48] G. Alemu, A. Abossie, and Z. Yohannes, “Current status of intestinal parasitic infections and associated factors among primary school children in Birbir town, Southern Ethiopia,” *BMC Infectious Diseases*, vol. 19, no. 1, p. 270, 2019.
[49] G. Beyene and H. Tasew, "Prevalence of intestinal parasite, Shigella and Salmonella species among diarrheal children in Jimma health center, Jimma southwest Ethiopia: A cross sectional study," *Annals of Clinical Microbiology and Antimicrobials*, vol. 13, no. 1, p. 10, 2014.

[50] H. S. Mekonnen and D. T. Ekubagawargie, "Prevalence and factors associated with intestinal parasites among under-five children attending Woreta Health Center, Northwest Ethiopia," *BMC Infectious Diseases*, vol. 19, no. 1, p. 256, 2019.

[51] H. Weldesenbet, A. Worku, and T. Shumbej, "Prevalence, infection intensity and associated factors of soil transmitted helminths among primary school children in Garege zone, South Central Ethiopia: A cross-sectional study design," *BMC Research Notes*, vol. 12, no. 1, p. 231, 2019.

[52] J. D. King, T. Endeshaw, E. Escher et al., "Intestinal parasite prevalence in an area of Ethiopia after implementing the SAFE strategy, enhanced outreach services, and health extension program," *PLoS Neglected Tropical Diseases*, vol. 7, no. 6, Article ID e2223, 2013.

[53] L. Eshetu, R. Dabsu, and G. Tadele, "Prevalence of intestinal parasites and its risk factors among food handlers in food services in Nekemte town, west Oromia, Ethiopia," *Research and Reports in Tropical Medicine*, vol. 10, pp. 25–30, 2019.

[54] M. B. Shiferaw, A. M. Zegeye, and A. D. Mengistu, "Helminth infections and practice of prevention and control measures among pregnant women attending antenatal care at Anbesame health center, Northwest Ethiopia," *BMC Research Notes*, vol. 10, no. 1, p. 274, 2017.

[55] M. Ayelgn, L. Worku, G. Ferede, and Y. Wondimeneh, "A 5 year retrospective analysis of common intestinal parasites at Poly Health Center, Gondar, Northwest Ethiopia," *BMC Research Notes*, vol. 12, no. 1, p. 697, 2019.

[56] M. Getachew, K. Tafess, A. Zeynudin, and D. Yewhalaw, "Prevalence Soil Transmitted Helminthiasis and malaria co-infection among pregnant women and risk factors in Gilgel Gibe dam Area, Southwest Ethiopia," *BMC Research Notes*, vol. 6, no. 1, p. 263, 2013.

[57] M. Lewetegn, M. Getachew, T. Kebede, G. Tadesse, and T. Asfaw, "Prevalence of intestinal parasites among preschool children and maternal KAP on prevention and control in Senbete and Bete Towns, North Shoa, Ethiopia," *International Journal of Biomedical Materials Research*, vol. 7, no. 1, pp. 1–7, 2019.

[58] M. Seid, T. Dejenie, and Z. Tomass, "Prevalence of intestinal helminths and associated risk factors in rural schoolchildren in Were-Abaye sub-district, Tigray region, northern Ethiopia," *Acta Parasitologica Globalis*, vol. 6, no. 1, 2015.

[59] M. Gebreselassie and Z. Tomas, "Prevalence of intestinal parasites and associated risk factors in school children of Aksum Town, Northern Ethiopia," *Acta Parasitologica Globalis*, vol. 6, no. 1, pp. 42–48, 2015.

[60] B. Dobo, M. Tadesse, and M. Birmeeka, "Prevalence and associated risk factors of intestinal parasitic infections among school children in Bamo no.2 primary school, Adele town, East Arsi, Ethiopia," *Sub-Saharan African Journal of Medicine*, vol. 6, no. 2, pp. 77–85, 2019.

[61] S. Zenu, E. Alemayehu, and K. Woldemichael, "Prevalence of intestinal parasitic infections and associated factors among street children in Jimma town; south West Ethiopia in 2019: A cross sectional study," *BMC Public Health*, vol. 19, no. 1, 2019.

[62] T. Jember, "Current prevalence of intestinal parasites emphasis on hookworm and schistosoma mansoni infections among patients at workemeda health center, northwest Ethiopia," *Clinical Microbiology: Open Access*, vol. 3, p. 4, 2014.

[63] T. Menjetta, T. Simion, W. Anjulo et al., "Prevalence of intestinal parasitic infections in Hawassa University students' clinic, Southern Ethiopia: A 10-year retrospective study," *BMC Research Notes*, vol. 12, no. 1, p. 702, 2019.

[64] T. Hailegebril, "Prevalence of intestinal parasitic infections and associated risk factors among students at Dona Berber primary school, Bahir Dar, Ethiopia," *BMC Infectious Diseases*, vol. 17, no. 1, p. 362, 2017.

[65] T. Tefera and G. Mebrie, "Prevalence and predictors of intestinal parasites among food handlers in Yebu Town, southwest Ethiopia," *PLoS One*, vol. 9, no. 10, Article ID e110621, 2014.

[66] T. Weygahu, T. Tsalla, B. Seifu, and T. Teklu, "Prevalence of intestinal parasitic infections among highland and lowland dwellers in Gamo area, South Ethiopia," *BMC Public Health*, vol. 13, no. 1, p. 151, 2013.

[67] T. Ibrahim, E. Zemene, Y. Asres et al., "Epidemiology of soil-transmitted helminths and Schistosoma mansoni: a base-line survey among school children, Ejai, Ethiopia," *The Journal of Infection in Developing Countries*, vol. 12, 2018.

[68] T. Addisu and A. Muche, "A survey of soil-transmitted helminths infections and schistosomiasis mansoni among school children in libo-kemkem district, northwest Ethiopia: cross sectional study," *American Journal of Health Research*, vol. 3, no. 2, p. 57, 2015.

[69] T. Eyamo, M. Girma, T. Alemayehu, and Z. Bedewi, "Soil-transmitted helminths and other intestinal parasites among schoolchildren in southern Ethiopia," *Research and Reports in Tropical Medicine*, vol. 10, pp. 137–143, 2019.

[70] T. Workneh, A. Esmael, and M. Ayichiluhm, "Prevalence of intestinal parasitic infections and associated factors among Debre elias primary schools children, East gojam zone, Amhara region, north west Ethiopia," *Journal of Bacteriology & Parasitology*, vol. 05, no. 01, 2014.

[71] T. Zemene and M. B. Shiferaw, "Prevalence of intestinal parasitic infections in children under the age of 5 years attending the Debre Birhan referral hospital, North Shoa, Ethiopia," *BMC Research Notes*, vol. 11, no. 1, 2018.

[72] T. Teshale, S. Belay, D. Tadesse, A. Awala, and G. Teklay, "Prevalence of intestinal helminths and associated factors among school children of Medebay Zana wereda; North Western Tigray, Ethiopia 2017," *BMC Research Notes*, vol. 11, no. 1, p. 444, 2018.

[73] Y. Tegegne, T. Wondmagegn, L. Worku, and A. Jejaw Zeleke, "Prevalence of intestinal parasites and associated factors among pulmonary tuberculosis suspected patients attending university of gondar hospital, gondar, northwest Ethiopia," *J Parasitol Res*, vol. 2018, Article ID 9372145, 6 pages, 2018.

[74] Y. Belyhun, G. Medhin, A. Amberbir et al., "Prevalence and risk factors for soil-transmitted helminth infection in mothers and their infants in Butajira, Ethiopia: a population based study," *BMC Public Health*, vol. 10, no. 1, p. 21, 2010.

[75] Y. Aleka, S. G/egziabher, W. Tamir, M. Birhane, and A. Alemu, "Prevalence and associated risk factors of intestinal parasitic infection among under five children in University of Gondar Hospital, Gondar, Northwest Ethiopia," *Biomedical Research and Therapy*, vol. 2, no. 8, pp. 20–27, 2015.

[76] T. Gebrehiwot, M. San Sebastian, K. Edin, and I. Goicolea, "Health workers’ perceptions of facilitators of and barriers to...
institutional delivery in Tigray, Northern Ethiopia,” BMC Pregnancy and Childbirth, vol. 14, no. 1, p. 137, 2014.

[77] Z. Mekonnen, S. Suleman, A. Biruksew, T. Tefeira, and L. Chelkela, “Intestinal polyparasitism with special emphasis to soil-transmitted helmiths among residents around Gilgel Gibe Dam, Southwest Ethiopia: a community based survey,” BMC Public Health, vol. 16, no. 1, 2016.

[78] D. G. Feleke and H. Hadush, “Prevalence of intestinal parasitic infections in St. Marry hospital, Axum, northern Ethiopia: a retrospective study,” Journal of Tropical Diseases, vol. 05, no. 01, 2017.

[79] H. M. Mengist, O. Zewdie, and A. Belew, “Intestinal helmithic infection and anemia among pregnant women attending ante-natal care (ANC) in East Wollega, Oromia, Ethiopia,” BMC Research Notes, vol. 10, no. 1, p. 440, 2017.

[80] D. Tegen, D. Damtie, and T. Hailegebrial, “Prevalence and associated risk factors of human intestinal protozoan parasitic infections in Ethiopia: a systematic review and meta-analysis,” Journal of parasitology research, vol. 2020, pp. 1–15, Article ID 8884064, 2020.

[81] World Health Organization, “Soil-transmitted helmith infections,” 2022, https://rb.gy/cvx7p.

[82] R. Seguí, C. Muñoz-Antoli, D. R. Klisiowicz et al., “Prevalence of intestinal parasites, with emphasis on the molecular epidemiology of Giardia duodenalis and Blastocystis sp,” The Parana gua Bay, Brazil: A Community Survey, vol. 11, no. 1, p. 490, 2018.

[83] P. Suntaravitun and A. Dokmai kaw, “Prevalence of intestinal parasites and associated risk factors for infection among rural communities of Chachoengsao Province, Thailand,” Korean Journal of Parasitology, vol. 56, no. 1, 39 pages, 2018.

[84] S. Ojja, S. Kisaka, M. Ediau et al., “Prevalence, intensity and factors associated with soil-transmitted helmiths infections among preschool-age children in Hoima district, rural western Uganda,” BMC Infectious Diseases, vol. 18, no. 1, p. 408, 2018.

[85] F. Zeukeng, V. H. M. Tchinda, J. D. Bigoga et al., “Co-infections of malaria and geohelmintiasis in two rural communities of Nkassomo and Vian in the Mfou health district, Cameroon,” PLoS Neglected Tropical Diseases, vol. 8, no. 10, Article ID e3236, 2014.

[86] T.-S. Yong, J.-Y. Chai, W.-M. Sohn et al., “Prevalence of intestinal helmiths among inhabitants of Cambodia (2006-2011),” Korean Journal of Parasitology, vol. 52, no. 6, pp. 661–666, 2014.

[87] B. Matthys, M. Bobieva, G. Karimova et al., “Prevalence and risk factors of helmiths and intestinal protozoa infections among children from primary schools in western Tajikistan,” Parasites and Vectors, vol. 4, no. 1, p. 195, 2011.

[88] J.-Y. Chai, W.-M. Sohn, B.-K. Jung et al., “Intestinal helminths recovered from humans in xiang khouang province, Lao PDR with a particular note on haplorchis pumili in-infection,” Korean Journal of Parasitology, vol. 53, no. 4, pp. 439–445, 2015.

[89] Y. Rajoo, S. Ambu, Y. A. L. Lim et al., “Neglected intestinal parasites, malnutrition and associated key factors: a population based cross-sectional study among indigenous communities in Sarawak, Malaysia,” PloS One, vol. 12, no. 1, Article ID e0170174, 2017.

[90] Z. Animaw, A. Melese, H. Demelash, G. Seyoum, and A. Abebe, “Intestinal parasitic infections and associated factors among pregnant women in Ethiopia: a systematic review and meta-analysis,” BMC Pregnancy and Childbirth, vol. 21, no. 1, p. 474, 2021.

[91] Centers for Disease Control and Prevention, “Parasites-as-carisiasis,” 2020, https://rb.gy/hlyfijj.

[92] T. Schmidlin, E. Hürlimann, K. D. Silué et al., “Effects of hygiene and defecation behavior on helmiths and intestinal protozoa infections in Taabo, Côte d’Ivoire,” PLoS One, vol. 8, no. 6, Article ID e65722, 2013.

[93] S. A. Schtle, P. Ghowes, I. Kroidl et al., “Ascaris lumbricoides infection and its relation to environmental factors in the Mbeya region of Tanzania, a cross-sectional, population-based study,” PLoS One, vol. 9, no. 3, Article ID e92032, 2014.

[94] E. Butera, A. Mukabutera, E. Nserekoto et al., “Prevalence and risk factors of intestinal parasites among children under two years of age in a rural area of Rutsiro district, Rwanda—a cross-sectional study,” The Pan African medical journal, vol. 32, p. 11, 2019.

[95] L. S. Galgamuwa, D. Iddawela, and S. D. Dharmaratne, “Prevalence and intensity of Ascaris lumbricoides infections in relation to undernutrition among children in a tea plantation community, Sri Lanka: A cross-sectional study,” BMC Pediatrics, vol. 18, no. 1, 2018.

[96] S. Sungkar, A. P. N. Pohan, A. Ramadani et al., “Heavy burden of intestinal parasite infections in Kalena Rongo village, a rural area in South West Sumba, eastern part of Indonesia: a cross sectional study,” BMC Public Health, vol. 15, no. 1, Article ID 1296, 2015.

[97] C. Dold and C. V. Holland, “Ascaris and ascariasis,” Microbes and Infection, vol. 13, no. 7, pp. 632–637, 2011.

[98] Centers for Disease Control and Prevention, “Parasites-hookworm,” 2022, https://www.cdc.gov/parasites/hookworm/index.html.

[99] S. Brooker, P. J. Hotez, and D. A. P. Bundy, “Hookworm-related anaemia among pregnant women: a systematic review,” PLoS Neglected Tropical Diseases, vol. 2, no. 9, Article ID e291, 2008.

[100] A. Assefa, B. Erko, S. G. Gundersen, G. Medhin, and N. Berhe, “Current status of Schistosoma mansoni infection among previously treated rural communities in the Abbey and Didessa Valleys, Western Ethiopia: implications for sustainable control,” PLoS One, vol. 16, no. 2, Article ID e0247312, 2021.

[101] A. O. Forson, I. Arthur, M. Olu-Taiwo, K. C. Glover, P. J. Pappoe-Ashong, and P. F. Ayeh-Kumi, “Intestinal parasitic infections and risk factors: a cross-sectional survey of some school children in a suburb in Accra, Ghana,” BMC Research Notes, vol. 10, no. 1, p. 485, 2017.

[102] H. Sacolo-Gwebu, M. Chimbari, and C. Kalinda, “Prevalence and risk factors of schistosomiasis and soil-transmitted helminthiasis among preschool aged children (1–5 years) in rural KwaZulu-Natal, South Africa: a cross-sectional study,” Infectious Diseases of Poverty, vol. 8, no. 1, 2019.

[103] S. Hussain, D. Assegu, and T. Shimelis, “Prevalence and risk factors of intestinal parasites among children under two years of age in a rural area of Rutsiro district, Rwanda—a cross-sectional study,” The Pan African medical journal, vol. 32, p. 11, 2019.

[104] M. Kabuyaya, M. J. Chimbari, T. Manyangadze, and S. Mukaratirwa, “Schistosomiasis risk factors based on the infection status among school-going children in the Ndumo area, uMkhan yakude district, South Africa,” Southern African Journal of Infectious Diseases, vol. 32, no. 2, pp. 67–72, 2017.

[105] Centers fo Disease Prevention and Control, “Parasites—Trichuriasis (also known as Whipworm Infection),” 2020, https://rb.gy/40qdyo.
[106] J. E. Bennett, R. Dolin, and M. J. Blaser, *Mandell, Douglas, and Bennett’s Principles and Practice of Infectious Diseases E-Book*, Elsevier Health Sciences, Amsterdam Netherlands, 2019.

[107] O. A. Adeleke, P. Yogeswaran, and G. Wright, “Intestinal helminth infections amongst HIV-infected adults in Mthatha General Hospital, South Africa,” *Afr J Prim Health Care Fam Med*, vol. 7, no. 1, p. 910, 2015.

[108] Medscape, “Hymenolepiasis,” 2020, https://emedicine.medscape.com/article/998498-overview.

[109] Medscape, “Taenia Infection,” 2018, https://emedicine.medscape.com/article/999727-overview.

[110] Ethiopian Federal Ministry of Health, “Hygiene and environmental health module. Beef tapeworm,” 2022, https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=198&section=1.3.1.

[111] M. L. A. R. de Alegría, A. Nindia, M. Moreno et al., “Prevalence of Strongyloides stercoralis and other intestinal parasite infections in school children in a rural area of Angola: a cross-sectional study,” *The American Journal of Tropical Medicine and Hygiene*, vol. 97, no. 4, 2017.

[112] M. L. McKenna, S. McAtee, P. E. Bryan et al., “Human intestinal parasite burden and poor sanitation in rural Alabama,” *The American Journal of Tropical Medicine and Hygiene*, vol. 97, no. 5, 2017.

[113] Centers for Disease Prevention and Control, “Parasites—enterobiasis (also known as pinworm infection),” 2020, https://rb.gy/xkpn50.

[114] B. Alemnew, G. Gedewaf, G. Diress, and A. D. Bizuneh, “Prevalence and factors associated with intestinal parasitic infections among food handlers working at higher public University student’s cafeterias and public food establishments in Ethiopia: A systematic review and meta-analysis,” *BMC Infectious Diseases*, vol. 20, no. 1, p. 156, 2020.

[115] L. Chelkeba, Z. Mekonnen, Y. Alemu, and D. Emana, “Epidemiology of intestinal parasitic infections in preschool and school-aged Ethiopian children: a systematic review and meta-analysis,” *BMC Public Health*, vol. 20, no. 1, 2020.

[116] World Health Organization, “Ethiopian school-based deworming campaign targets 17 million children,” 2021, https://www.afro.who.int/news/ethiopian-school-based-deworming-campaign-targets-17-million-children.

[117] L. Ben Ayed and S. Sababhi, “Entamoeba histolytica,” 2017, https://www.waterpathogens.org/sites/default/files/Entamoeba%20histolytica_3.pdf.