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

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Review Article

Parasitic infection is one of the major health problems where more than 3.5 billion people are infected globally. Parasitic infections result in 450 million and 200,000 annual morbidities and mortalities, respectively [1]. Protozoan infections are among such infections. They are highly prevalent in preschool children in developing countries [2, 3]. E. histolytica/dispar, G. lamblia/duodenalis, and Cryptosporidium spp. are the major common pathogenic intestinal protozoan species globally reported [4].

E. histolytica has an annual incidence rate of five million cases, affects approximately 500 million people worldwide, and results in 50 million annual symptomatic diseases and 100,000 deaths [5]. It too results in 2.2 million disability-adjusted life years [6, 7]. G. lamblia/duodenalis infects 280 million people annually. It results in two and half million cases of diarrhea every year in resource-poor countries alone. In these countries, the prevalence of giardia infection is acquired during early infancy and it reaches up to 30% in children younger than 10 years of age [8]. The global prevalence of cryptosporidiosis is 1 to 4.5% in developed countries and 3 to 20% in developing countries. Its infection rate in AIDS patients ranges from 3 to 20% in the United States and 50 to 60% in Africa and Haiti [9]. It results in an estimate of 8.37 million DALYs with cryptosporidiosis [10].
Transmission of *E. histolytica*, *G. lamblia/duodenalis*, and cryptosporidiosis is through the oral-fecal route following direct or indirect contact with the infectious stages, including human-to-human, zoonotic, waterborne, and foodborne transmission [11]. However, *Cryptosporidium* may also be transmitted airborne [12]. Eating unwashed fruits, nail-biting, sucking fingers, and contact with infected family members are also key factors contributing to the increased HIPPIs [13, 14].

Protozoan infections are serious public health concerns and are responsible for iron deficiency anemia, growth retardation, and physical and mental health problems among children. They also lead to nutritional depletion, poor immunity in infants, mucosal loss and lymphatic leakages, and local hemorrhages [2].

Despite remarkable development in medical science in recent years, protozoan parasitic infections remain serious health issues in developing countries like Ethiopia [15]. Low level of environmental sanitation, personal and food hygiene, contamination of water with human excreta, and lack of awareness about simple health promotion practices such as personal hygiene and food hygiene make HIPPIs the most common problems in Ethiopia [16–19]. The prevalence of HIPPIs in Ethiopia is different in different parts of the country. However, there is no summarized pooled overall prevalence of HIPPIs. Therefore, this systematic review and meta-analysis study is aimed at producing the pooled prevalence and factors associated with HIPPIs from available studies in Ethiopia.

2. Methods

2.1. Study Design and Setting. Ethiopia is located in the horn of Africa. It is bounded by Eritrea to the north, Djibouti and Somalia to the east, Sudan and South Sudan to the west, and Kenya to the south. Currently, the Ethiopian population is estimated to be 113,620,337 with 21.3% (24,463,423) people living in the urban area and a median age of 19.5 years. Ethiopia’s population is equivalent to 1.47% of the total world population. The population density in Ethiopia is 115/km² (298 people/mi²) [20]. The total land area is 1,104,300 km² [21].

2.2. Search Strategies. Articles written in English were searched from online public databases, namely, PubMed/ MEDLINE, ScienceDirect, Web of Science, Google Scholar, Hinari, WorldCat, and Cochrane Library [22], using core search terms and phrases: “prevalence,” “intestinal protozoan parasite,” “associated factors,” and “Ethiopia.” The search terms were used separately and in combination using Boolean operators like “OR” or “AND.” Besides, Gray literature was searched through the review of available references. Searching of pieces of literature included in this meta-analysis was conducted from December 2019 to January 2020.

2.3. Inclusion and Exclusion Criteria. Studies that were written in the English language, reporting about the prevalence of HIPPIs and their associated risk factors in Ethiopia, published from 2008 to January 2020, with sample sizes above 100 [23] were included in the study. Studies conducted on HIV/AIDS patients, meta-analysis, and review articles were excluded from this systematic review and meta-analysis study.

2.4. Data Extraction. The data extraction protocol was prepared and evaluated by all authors. The data extraction protocol consists of the name of the author and year of publication, region, nature of study subjects (school-age children, food handlers, preschool-age children, patients, rural dwellers, and street dwellers), total sample size, number of positive cases, estimated prevalence, species of intestinal parasites, and potential risk factors associated with individual species of HIPPIs.

2.5. Quality Assessment of Individual Studies Included in the Meta-Analysis. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess the overall quality of evidence [24]. The quality of each study was declared using the three major assessment tools (methodological quality, comparability, and outcome and statistical analysis of the study). Two points were given to each criterion. Publications with a total score of 5–6 points were considered to be high, 4 points to be moderate, and 0–3 points to be low-quality publications [24]. The association between HIPPIs and associated risk factors was calculated in the form of the log odds ratio. The odds ratio was calculated for the common associated risk factors of the reported studies.

2.6. Risk of Publication Bias across Studies Included in This Meta-Analysis. The risks of publication bias across studies were assessed using funnel plot symmetry and Egger’s test. Egger’s test (P value < 0.05) was used to determine the presence of publication bias across studies.

2.7. Outcomes of the Study. Intestinal protozoan parasitic infection and associated risk factors of HIPPIs were the two major outcome variables.

2.8. Data Analysis. The pooled prevalence of HIPPIs was calculated by dividing the total positive cases to the total study subjects included in this meta-analysis. Cochran’s Q test and I² statistics were used to assess heterogeneity among the studies [25]. There was a clear heterogeneity on the prevalence of HIPPIs across studies included in this meta-analysis; we used a random-effects model to estimate the pooled effect size. To sort out the causes of heterogeneity, we conduct a subgroup analysis based on the region of the study, the nature of study participants, study year, and sample size included in individual studies. The presence of publication bias was assessed using Egger’s test and symmetry of the funnel plot. The cause of publication bias was assessed using a sensitivity test and regression test. Forest plot format was used to present the pooled point prevalence with 95% CI. A log odds ratio was used to decide the association between associated risk factors and HIPPIs among respondents included in the studies. The meta-analysis was conducted using Stata software (version 14, StataCorp, College Station, TX), where P < 0.05 was considered statistically significant.
3. Results

A total of 286 articles on the prevalence and associated risk factors of intestinal parasitic infections in Ethiopia were retrieved. Forty-eight of these articles were excluded due to duplicates. From the remaining 238 articles, 65 were excluded after review of their titles (titles were not related to HIPPIs) and 80 were excluded after review of abstracts (lack of full information about protozoan parasites). The remaining 93 full-text articles were accessed and assessed for eligibility based on the inclusion criteria and information indicated in the data extraction protocol. As a result, 48 articles were further excluded in the data extraction process primarily due to the outcome of interest, and they did not have OR, 95% CI, and the number of positive cases (meaning the report was only based on estimated prevalence percent). Thus, only 45 (15.7%) of the studies met the eligibility criteria and were included in the final systematic review and meta-analysis study (Figure 1).

3.1. Characteristics of Original Studies Included in the Meta-Analysis. Out of the 45 screened studies, 44 (97.5%) of them were cross-sectional and one (2.5%) was a case-control study. A total of 131,916 study participants were involved, and the sample size of the studies ranged from 127 to 89,423. Twenty (44.44%) of the studies were from Amhara, 8 (17.77%) from SNNPR, 6 (13.33%) from Oromia, 2 (4.44%) from Addis Ababa, 1 (2.22%) from Dire Dawa, 2 (4.44%) from Benishangul-Gumuz, and 6 (13.33%) from Tigray regions (Table 1). Unfortunately, there were no studies reported from Afar, Harari, Gambela, and Somali regional states of Ethiopia.

3.2. Quality of Studies Included in the Meta-Analysis. The quality score of each original study ranged between three and the highest six (Table 1). The overall quality of the articles included in this meta-analysis is very good.

3.3. Prevalence of Intestinal Protozoan Parasitic Infections in Ethiopia. The lowest prevalence of IPPIs was reported from Gondar (2.4%) [26] while the highest prevalence (69.2%) was reported from Delgi primary school, Amhara region [27]. The overall pooled prevalence of HIPPIs was 25.01% (95% CI: 20.08%-29.95%) (Figure 2). High heterogeneity ($I^2 = 99.4\%, P \leq 0.001$) was observed across studies included in the studies.
Table 1: Characteristics of the study subjects included in the eligible articles used for this review.

| Source                        | Year | Region          | Study area               | Sample size | Cases | Prevalence (95% CI)         | Quality score |
|-------------------------------|------|-----------------|--------------------------|-------------|-------|-----------------------------|---------------|
| Andargie et al.               | 2008 | Amhara          | Gondar food handler      | 127         | 3     | 2.4% (0.48-6.90)            | 4             |
| Ayalew et al.                 | 2008 | Dire Dawa       | Lege Dini watershed      | 655         | 311   | 47.50% (42.30-53.10)        | 3             |
| Abera et al.                  | 2010 | Amhara          | Bahir Dar food handler   | 384         | 76    | 19.79% (15.60-24.80)        | 6             |
| Tigabu et al.                 | 2010 | Benishangul     | Pawi                     | 384         | 133   | 34.6% (28.90-41.04)         | 6             |
| Ayalew et al.                 | 2011 | Amhara          | Delgi primary school     | 704         | 487   | 69.20% (63.10-75.60)        | 6             |
| Yihenew                       | 2011 | Amhara          | Foger Awuramba           | 392         | 58    | 14.8% (11.20-19.10)         | 3             |
| Gelaw et al.                  | 2013 | Amhara          | Gondar health center     | 304         | 40    | 13.20% (9.40-17.90)         | 6             |
| Wegayehu et al.               | 2013 | Oromia          | North Shewa Zone         | 384         | 95    | 24.70% (20.00-30.00)        | 6             |
| Wegayehu et al.               | 2013 | SNNPR           | Gamo rural residence     | 858         | 189   | 22.0% (18.90-25.40)         | 6             |
| Abossie and Seid              | 2014 | SNNPR           | Chencha town primary school | 400       | 112   | 28% (23.05-33.60)          | 6             |
| Andualem                      | 2014 | Amhara          | Motta Town primary school | 364        | 70    | 19.50% (15.20-24.60)        | 6             |
| Beyene and Tasew              | 2014 | Oromia          | Jimma health center      | 260         | 43    | 15.00% (11.90-22.20)        | 5             |
| Firdu et al.                  | 2014 | SNNPR           | Yirgaem health center    | 230         | 39    | 16.95% (12.05-23.20)        | 6             |
| Kidane et al.                 | 2014 | Tigray          | Wukro Town health center | 384         | 163   | 42% (36.20-49.50)           | 6             |
| Mekonnen et al.               | 2014 | Addis Ababa     | Addis Ababa              | 355         | 63    | 17.7% (13.60-22.70)         | 6             |
| Tulu et al.                   | 2014 | Oromia          | Delo-Mena, Bale Zone     | 340         | 26    | 3.60% (4.90-11.20)          | 6             |
| Workneh et al.                | 2014 | Amhara          | Debre Elias primary school | 541      | 44    | 8.13% (5.90-10.90)          | 6             |
| Aklilu et al.                 | 2015 | Addis Ababa     | Addis Ababa University   | 172         | 86    | 50% (39.90-61.70)           | 3             |
| Aleka et al.                  | 2015 | Amhara          | Gondar University Hospital | 277       | 10    | 3.6% (1.70-6.60)           | 6             |
| G/Silassie et al.             | 2015 | Tigray          | Aksum Town primary school | 404       | 127   | 31.4% (26.20-37.40)         | 4             |
| Deneke                        | 2016 | Amhara          | Ankeber                  | 403         | 240   | 60.0% (52.20-67.60)         | 3             |
| Tulu et al.                   | 2016 | Oromia          | Dolomena (Balie Zone)    | 492         | 48    | 9.8% (7.10-12.90)           | 6             |
| Birmeke et al.                | 2017 | SNNPR           | Gurage zone primary school | 450      | 97    | 21.60% (17.40-26.20)        | 6             |
| Gebretsadik                   | 2017 | Benishangul     | Homsha district           | 395         | 106   | 26.8% (21.90-32.40)         | 6             |
| Hailegebriel                  | 2017 | Amhara          | Bahir Dar                | 359         | 129   | 35.9% (30.00-42.60)         | 6             |
| Senbeta                       | 2017 | Tigray          | Adigrat primary school   | 309         | 21    | 6.80% (4.20-10.38)          | 5             |
| Berhe et al.                  | 2018 | Tigray          | Mekele                   | 226         | 101   | 45.3% (36.40-54.30)         | 5             |
| Dobo                          | 2018 | SNNPR           | Hawasa                   | 89423       | 39895 | 44.6% (44.20-45.05)         | 3             |
| Gebreyohanns et al.           | 2018 | Tigray          | Addiremets town          | 411         | 13    | 3.2% (1.68-5.40)            | 5             |
| Tegegne et al.                | 2018 | Amhara          | Gondar University Hospital | 256       | 14    | 5.5% (2.90-9.17)           | 6             |
| Alemu et al.                  | 2019 | SNNPR           | Gamogofa Zone primary school | 351       | 26    | 7.4% (4.80-10.80)          | 6             |
| Asires et al.                 | 2019 | Amhara          | East and West Gojam      | 344         | 96    | 27.9% (22.60-34.07)         | 5             |
| Ayalew et al.                 | 2019 | Amhara          | Bahir Dar primary school | 418         | 71    | 16.98% (13.05-21.15)        | 5             |
| Ayelgn et al.                 | 2019 | Amhara          | Gondar poly health center | 13329     | 3760  | 28.2% (27.30-29.10)         | 5             |
| Eshetu et al.                 | 2019 | Oromia          | Nekermint               | 240         | 73    | 30.4% (23.80-38.20)         | 5             |
| Gebrecherkos et al.           | 2019 | Amhara          | University of Gondar     | 150         | 45    | 30% (21.80-40.10)          | 6             |
| Kuma et al.                   | 2019 | SNNPR           | Wolayta Sodo University  | 233         | 47    | 20.2% (14.80-26.80)         | 5             |
| Lewetegna et al.              | 2019 | Amhara          | Senbet and Bete Towns    | 214         | 60    | 28.1% (21.30-36.08)         | 6             |
| Menjeta et al.                | 2019 | SNNPR           | Hawusa University Clinic | 13679     | 3782  | 27.6% (26.70-28.50)         | 4             |
| Sewunet and Tekelia           | 2019 | Amhara          | Woreta                   | 310         | 52    | 16.8% (12.50-21.90)         | 5             |
| Shimeles et al.               | 2019 | Amhara          | Chagni food handler      | 400         | 40    | 10% (7.10-13.60)            | 6             |
| Sitoaw et al.                 | 2019 | Amhara          | Jawi primary school      | 406         | 105   | 25.9% (21.10-31.30)         | 6             |
| Tadesse et al.                | 2019 | Oromia          | Bamo no. 2 primary school | 417       | 74    | 17.7% (13.90-22.20)         | 5             |
| Tigabu et al.                 | 2019 | Amhara          | Shahura health center    | 364         | 145   | 39.84% (33.60-46.90)        | 6             |
| Berhe et al.                  | 2020 | Tigray          | Adigrat                 | 418         | 248   | 59.30 (52.20-67.20)         | 6             |

SNNPR: Southern Nations, Nationalities, and People’s Region.
| Author (year) | ES (95% CI) |
|--------------|-------------|
| Wegayehu et al., 2013 | 24.70 (20.00, 30.00) |
| Beyene and Tasew, 2014 | 16.50 (11.90, 22.20) |
| Tulu et al., 2014 | 7.64 (4.90, 11.20) |
| Tulu et al., 2016 | 9.80 (7.10, 12.90) |
| Eshetu et al., 2019 | 30.40 (23.80, 38.20) |
| Tadesse et al., 2019 | 17.70 (13.90, 22.20) |
| Subtotal (I-squared = 92.3%, P ≤ 0.001) | 17.36 (11.19, 23.52) |

| Author (year) | ES (95% CI) |
|--------------|-------------|
| Andargie et al., 2008 | 2.40 (0.48, 6.90) |
| Abera et al., 2010 | 19.79 (15.60, 24.80) |
| Yihenew, 2011 | 14.80 (11.20, 19.10) |
| Ayalew et al., 2011 | 69.20 (63.10, 75.60) |
| Gelaw et al., 2013 | 13.20 (9.40, 17.90) |
| Workneh et al., 2014 | 8.13 (5.90, 10.90) |
| Asemahagn, 2014 | 19.50 (15.20, 24.60) |
| Aleka et al., 2015 | 3.60 (1.70, 6.60) |
| Deneke, 2016 | 60.00 (52.20, 67.60) |
| Hailegebriel, 2017 | 35.90 (30.00, 42.60) |
| Tegegne et al., 2018 | 5.50 (2.90, 9.17) |
| Lewetegn et al., 2019 | 28.10 (21.30, 36.08) |
| Shimeles et al., 2019 | 10.00 (7.10, 13.60) |
| Tigabu et al., 2019 | 39.84 (33.60, 46.90) |
| Asires et al., 2019 | 27.90 (22.60, 34.07) |
| Ayelgn et al., 2019 | 28.21 (27.30, 29.10) |
| Sewunet and Tekelia, 2019 | 16.80 (12.50, 21.90) |
| Gerebcherkos et al., 2019 | 30.00 (21.80, 40.10) |
| Sitotaw et al., 2019 | 25.90 (21.10, 31.30) |
| Ayalew et al., 2019 | 16.70 (13.05, 21.15) |
| Subtotal (I-squared = 98.5%, P ≤ 0.001) | 23.48 (17.35, 29.61) |

| Author (year) | ES (95% CI) |
|--------------|-------------|
| Wegayehu et al., 2013 | 22.03 (18.90, 25.40) |
| Firdu et al., 2014 | 16.95 (12.05, 23.20) |
| Abossie and Seid, 2014 | 28.00 (23.05, 33.60) |
| Birnka et al., 2017 | 21.60 (17.40, 26.20) |
| Dobo, 2018 | 44.61 (44.20, 45.05) |
| Kuma et al., 2019 | 20.20 (14.80, 26.80) |
| Menjetta et al., 2019 | 27.60 (26.70, 28.50) |
| Alemu et al., 2019 | 7.40 (4.80, 10.80) |
| Subtotal (I-squared = 99.6%, P ≤ 0.001) | 23.61 (13.86, 33.36) |

| Author (year) | ES (95% CI) |
|--------------|-------------|
| Kidane et al., 2014 | 42.00 (36.20, 49.50) |
| Gebreslassie, 2015 | 31.40 (26.20, 37.40) |
| Senbeta, 2017 | 6.80 (4.20, 10.38) |
| Gebreyohanns et al., 2018 | 3.20 (1.68, 5.40) |
| Berhe et al., 2018 | 45.30 (36.40, 54.30) |
| Berhe et al., 2020 | 59.30 (52.20, 67.20) |
| Subtotal (I-squared = 98.8%, P ≤ 0.001) | 31.03 (14.94, 47.12) |

| Author (year) | ES (95% CI) |
|--------------|-------------|
| Ayalew et al., 2008 | 47.50 (42.30, 53.10) |
| Subtotal (I-squared = 99.6%, P ≤ 0.001) | 47.50 (42.10, 52.90) |

| Author (year) | ES (95% CI) |
|--------------|-------------|
| Mekonnen et al., 2014 | 17.70 (13.60, 22.70) |
| Aklilu et al., 2015 | 50.00 (39.90, 61.70) |
| Subtotal (I-squared = 96.5%, P ≤ 0.001) | 33.45 (1.81, 65.10) |

| Author (year) | ES (95% CI) |
|--------------|-------------|
| Tigabu et al., 2010 | 34.60 (28.90, 41.04) |
| Gebretsadik, 2017 | 26.80 (21.90, 32.40) |
| Subtotal (I-squared = 72.4%, P = 0.057) | 30.55 (22.91, 38.18) |
| Overall (I-squared = 99.4%, P ≤ 0.001) | 25.01 (20.08, 29.95) |

Note: weights are from random effects analysis

Figure 2: Pooled prevalence of HIPPIs in Ethiopia including the regional level. Each square represents the effect size (ES) of individual studies, and the horizontal line represents the 95% CI. The diamond indicates the pooled effect, and the vertical dash lines indicate the overall estimate.
3.4. Subgroup Analysis. High pooled prevalence of HIPPIs was reported from Dire Dawa (47.5%, 95% CI: 42.10-52.9), followed by Addis Ababa (33.45%, 95% CI: 1.81-65.10), Tigray (31.03%, 95% CI: 14.94-47.12), and Benishangul-Gumuz (30.55%, 95% CI: 22.91-38.18), whereas the low prevalence of HIPPIs was observed in Oromia (17.35%, 95% CI: 11.17-23.53) followed by Amhara (23.48%, 95% CI: 17.35-29.61) and SNNPR (23.61%, 95% CI: 13.86-33.36). The pooled prevalence of HIPPIs of studies with sample sizes > 200 (24.89%, 95% CI: 19.86-29.93) was lower than that of studies having sample sizes ≤ 200 (27.12%, 95% CI: 2.2-56.45) (Table 2).

The highest pooled prevalence of HIPPIs was observed among patients (32.65%, 95% CI: 25.64-39.67) followed by school children (24.21%, 95% CI: 17.89-30.52), food handlers (22.24%, 95% CI: 12.94-31.54), urban dwellers (17.7%, 95% CI: 13.15-22.25), preschool children (15.81%, 95% CI: 2.23-29.40), and rural dwellers (13.29%, 95% CI: 0.85-25.72) (Table 2).

The pooled prevalence of HIPPIs was 31.28% (95% CI: 12.78-49.77), 25.30% (95% CI: 18.33-32.27), and 22.58% (95% CI: 17.52-27.64) observed among studies conducted from 2008 to 2012, 2013 to 2017, and 2018 to 2020, respectively (Table 2).

3.5. Common HIPPIs in Ethiopia. The pooled prevalence of *E. histolytica/dispar* was 14.09% (95% CI: 11.03-17.14) (Figure 3) followed by *G. lamblia* 10.03% (95% CI: 7.69-12.38) (Figure 4) and *Cryptosporidium* spp. 5.93% (95% CI: 2.95-8.91) (Figure 5) among study subjects in Ethiopia. There is no significant difference in the pooled prevalence of *E. histolytica/dispar*, *G. lamblia*, and *Cryptosporidium* spp. among regions included in this meta-analysis (P = 0.322, P = 0.168, and P = 0.088, respectively).

We perform a metaregression analysis to identify the sources of heterogeneity across studies. The analysis showed that the region of study (regression coefficient: 0.104, 95% CI: -0.032-0.239, and P = 0.131), nature of study subjects (regression coefficient: -0.158, 95% CI: -0.322-0.006, and P = 0.058), year of publication (regression coefficient: -0.029, 95% CI: -0.365-0.306, and P = 0.861), and sample size (regression coefficient: 0.041, 95% CI: -1.024-0.941, and P = 0.933) did not contribute for the heterogeneity.

3.6. Risk of Publication Bias across Studies Included in the Meta-Analysis. The funnel plot symmetry demonstrates the presence of publication bias among studies included in this meta-analysis (Figure 6). Similarly, Egger’s test results (P ≤ 0.001) indicate publication bias among studies. Sensitivity analysis was performed by recalculating the pooled prevalence of HIPPIs by sequentially removing one by one to identify the cause of publication bias. The pooled prevalence remained stable, and the result was not driven by individual studies included in the meta-analysis.

3.7. Factors Associated with HIPPIs in Ethiopia. In this meta-analysis, we have reviewed several potential risk factors associated with HIPPIs in Ethiopia. Family size, source of drinking water, open field defecation, handwashing habit, the habit of eating raw vegetables, and fingernail trimming and cleanliness habits were associated with HIPPIs. The association between fingernail trimming and cleanliness habits and intestinal protozoan parasitic infection in people of Ethiopia was computed from 12 studies [18, 28–38]. The pooled results showed that individuals with poor fingernail trimming and cleanliness habits were 1.7 times more likely to be infected with HIPPIs than their counterparts (OR: 1.7, 95% CI: 0.89-2.25, and P ≤ 0.001) (Supplementary 1 = S1).

The pooled results of 20 studies [17, 18, 27, 28, 31–34, 36–47] showed that handwashing habits were strongly associated with infection with intestinal protozoan parasitic infections in Ethiopia. The odds of having an intestinal parasitic infection was 2.82 times higher among people who did not wash their hands after defecation than people who wash their hands (OR: 2.82, 95% CI: 2.01-3.63) (S2).

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**Table 2: Prevalence of HIPPIs in Ethiopia by subgroups.**

| Variables | Characteristics | Number of studies | Sample size | Prevalence (95% CI) | I², P value |
|-----------|-----------------|-------------------|-------------|---------------------|-------------|
| Sample size | ≤200 | 3 | 449 | 27.12% (95% CI: -2.2-56.45) | 99.4%, P < 0.01 |
| | >200 | 42 | 131,467 | 24.89% (95% CI: 19.86-29.93) | 97.8%, P < 0.01 |
| Pooled prevalence of HIPPIs by year | 2008-2012 | 6 | 2646 | 31.28% (95% CI: 12.78-49.77) | 99.0%, P < 0.01 |
| | 2013-2017 | 20 | 7681 | 22.58% (95% CI: 17.52-27.64) | 96.7%, P = 0.01 |
| | 2018-2020 | 19 | 121,589 | 25.30% (95% CI: 18.33-32.27) | 99.6%, P < 0.01 |
| Nature of study participants | Food handlers | 7 | 1900 | 22.94% (95% CI: 19.86-29.93) | 96%, P < 0.01 |
| | Patients | 13 | 118,738 | 32.65% (95% CI: 25.64-39.67) | 99%, P < 0.01 |
| | Preschool children | 3 | 858 | 15.81% (95% CI: 2.23-29.40) | 96%, P < 0.01 |
| | School children | 18 | 8404 | 24.21% (95% CI: 17.89-30.52) | 97.7%, P < 0.01 |
| | Urban dwellers | 1 | 355 | 17.7% (95% CI: 13.15-22.25) | — |
| | Rural dwellers | 3 | 1661 | 13.29% (95% CI: 8.85-25.72) | 98.1%, P < 0.01 |
| Overall | 45 | 131,916 | 25.01% (95% CI: 20.08-29.95) | 99.4%, P < 0.01 |
The association between age and intestinal protozoan parasitic infections was analyzed from nine studies [18, 29, 31, 34, 41, 42, 47–49]. Age (children up to 14 years) was significantly associated with the prevalence of intestinal protozoan parasitic infections. The odds of having HIPPIs in children (up to 14 years) were 1.54 times higher than those in adults (OR: 1.54, 95% CI: 0.91-2.18) (S3).

The association between open field defecation and intestinal protozoan parasitic infection among people in Ethiopia was computed from six studies [3, 34, 35, 38, 42, 50]. People who practiced open field defecation were 2.91 times more likely to have intestinal protozoan parasitic infections than those who did not practice open field defecation (OR: 2.91, 95% CI: 1.60–4.21) (S4).

### Table: Prevalence of *E. histolytica/dispar* among Study Participants in Ethiopia

| Author (year)          | ES (95% CI)         |
|------------------------|---------------------|
| Oromia                 |                     |
| Wegayehu et al., 2013  | 3.60 (1.99, 6.12)   |
| Bekele et al., 2014    | 3.10 (1.30, 6.06)   |
| Tulu et al., 2014      | 5.00 (2.90, 8.01)   |
| Tulu et al., 2015      | 7.70 (5.40, 10.60)  |
| Eshetu et al., 2019    | 29.60 (23.10, 37.31)|
| Tadesse et al., 2019   | 10.30 (7.46, 13.88) |
| Subtotal (I-squared = 92.0%, P ≤ 0.001) | 8.73 (4.67, 12.79) |
| Amhara                 |                     |
| Andargie et al., 2018  | 1.60 (0.19, 5.68)   |
| Ogbu et al., 2018      | 12.76 (9.44, 16.86) |
| Yihmew, 2011           | 8.70 (6.00, 12.12)  |
| Ayele et al., 2011     | 27.30 (23.55, 31.42)|
| Gebraye et al., 2013   | 9.20 (6.12, 13.31)  |
| Workneh et al., 2014   | 6.70 (4.66, 9.21)   |
| Asemahagn, 2014        | 11.50 (8.31, 15.59) |
| Aleka et al., 2015     | 1.80 (0.58, 4.20)   |
| Deneke, 2016           | 50.90 (44.14, 58.32)|
| Hailegebriel, 2017     | 24.80 (19.65, 30.20)|
| Tekalegn et al., 2018  | 5.50 (2.98, 9.18)   |
| Lewenet et al., 2019   | 8.40 (4.98, 13.29)  |
| Shimeles et al., 2019  | 8.50 (5.88, 11.87)  |
| Tigatu et al., 2019    | 32.40 (26.80, 38.82)|
| Asires et al., 2019    | 24.10 (19.21, 29.91)|
| Ayele et al., 2019     | 16.80 (16.14, 17.55)|
| Sewunet and Tekela, 2019 | 6.80 (4.19, 10.35) |
| Gebrechorkos et al., 2019 | 20.70 (14.04, 29.33) |
| Sitotaw et al., 2019   | 5.90 (3.78, 8.79)   |
| Ayele et al., 2019     | 12.00 (8.87, 15.77) |
| Subtotal (I-squared = 97.2%, P ≤ 0.001) | 14.34 (10.68, 18.01)|
| SNNP                   |                     |
| Wegayehu et al., 2013  | 11.40 (9.27, 13.91) |
| Firdu et al., 2014     | 3.04 (1.22, 6.27)   |
| Abosie and Seid, 2014  | 16.25 (12.54, 20.71)|
| Birnaka et al., 2017   | 8.00 (5.60, 11.07)  |
| Dobo, 2018             | 25.66 (23.53, 26.00)|
| Kuma et al., 2019      | 16.40 (11.90, 22.88)|
| Menjetta et al., 2019  | 18.00 (17.30, 18.73)|
| Alemu et al., 2019     | 2.60 (1.12, 4.86)   |
| Subtotal (I-squared = 99.5%, P ≤ 0.001) | 12.66 (6.52, 18.79)|
| Tigray                 |                     |
| Kidane et al., 2014    | 23.20 (18.61, 28.52)|
| Gebreslassie, 2015     | 17.30 (13.50, 21.89)|
| Senbeta, 2017          | 4.50 (2.48, 7.60)   |
| Gebreyohannes et al., 2018 | 1.20 (0.39, 2.83) |
| Berhe et al., 2018     | 24.70 (18.33, 31.67)|
| Berhe et al., 2020     | 39.70 (33.90, 46.23)|
| Subtotal (I-squared = 98.2%, P ≤ 0.001) | 18.13 (8.18, 28.09)|
| Addis Ababa            |                     |
| Mekonnen et al., 2014  | 8.20 (5.40, 11.70)  |
| Aklilu et al., 2015    | 39.50 (30.70, 50.11)|
| Subtotal (I-squared = 97.2%, P ≤ 0.001) | 23.50 (~7.17, 54.17)|
| Benishangul            |                     |
| Tigabu et al., 2010    | 6.30 (4.00, 9.29)   |
| Gebretsadik, 2017      | 14.20 (10.70, 18.41)|
| Subtotal (I-squared = 90.9%, P = 0.001) | 10.12 (2.38, 17.86)|
| Overall (I-squared = 99.1%, P ≤ 0.001) | 14.09 (11.03, 17.14)|

Note: weights are from random effects analysis

Figure 3: The pooled prevalence of *E. histolytica/dispar* among study participants in Ethiopia.
The association between the habits of eating raw, unwashed, contaminated, leftover fruits and vegetables with intestinal protozoan parasitic infections was evaluated from nine studies [18, 27–29, 34, 35, 38, 44, 45]. The odds of having intestinal protozoan parasitic infections was 1.77 times higher among people who had habits of eating raw, unwashed, contaminated, leftover fruits and vegetables as compared with the counterparts (OR: 1.77, 95%; CI: 1.03-2.51) (S5).

The association between family education and intestinal protozoan parasitic infection among people in Ethiopia

| Author/year | ES (95% CI) |
|-------------|-------------|
| Wegayehu et al., 2013 | 13.80 (10.33, 18.05) |
| Beyene and Tasew, 2014 | 13.50 (9.37, 18.72) |
| Tulu et al., 2014 | 2.60 (1.21, 5.02) |
| Tulu et al., 2016 | 2.03 (0.97, 3.73) |
| Esbetu et al., 2019 | 0.83 (0.10, 3.01) |
| Tadesse et al., 2019 | 7.40 (5.05, 10.55) |
| Subtotal (I-squared = 92.8%, P ≤ 0.001) | 6.16 (2.85, 9.47) |

| Author/year | ES (95% CI) |
|-------------|-------------|
| Wegayehu et al., 2013 | 0.80 (0.02, 4.38) |
| Afera et al., 2010 | 7.00 (4.63, 10.23) |
| Yihene, 2011 | 4.30 (2.50, 6.94) |
| Ayalew et al., 2011 | 41.90 (37.25, 46.96) |
| Gelay et al., 2013 | 3.90 (2.03, 6.89) |
| Workneh et al., 2014 | 1.40 (0.63, 2.91) |
| Asemahagn, 2014 | 7.90 (5.94, 11.44) |
| Deneke, 2016 | 8.70 (6.04, 12.07) |
| Hailegebriel, 2017 | 11.40 (8.19, 15.49) |
| Lewetegn et al., 2019 | 19.60 (14.14, 26.52) |
| Shimeles et al., 2019 | 1.50 (0.55, 3.26) |
| Tigabu et al., 2019 | 7.40 (4.88, 10.79) |
| Asire et al., 2019 | 3.80 (2.01, 6.66) |
| Ayelgn et al., 2019 | 11.40 (10.80, 11.96) |
| Sewinet and Tekelia, 2019 | 10.00 (6.79, 14.19) |
| Gebrecheros et al., 2019 | 3.30 (1.08, 7.77) |
| Sitotaw et al., 2019 | 19.95 (15.84, 24.79) |
| Ayalew et al., 2019 | 4.80 (2.90, 7.38) |
| Subtotal (I-squared = 97.5%, P ≤ 0.001) | 9.03 (6.07, 11.99) |

| Author/year | ES (95% CI) |
|-------------|-------------|
| Wegayehu et al., 2013 | 10.60 (8.53, 13.02) |
| Firdu et al., 2014 | 9.60 (5.99, 14.48) |
| Abosie and Seid, 2014 | 11.75 (8.63, 15.62) |
| Biru et al., 2017 | 13.50 (10.36, 17.40) |
| Dobo, 2018 | 18.90 (16.86, 20.23) |
| Kumma et al., 2019 | 5.20 (2.66, 8.99) |
| Menjatta et al., 2019 | 9.60 (9.12, 10.16) |
| Almam et al., 2019 | 4.80 (2.82, 7.75) |
| Subtotal (I-squared = 99.4%, P ≤ 0.001) | 10.53 (5.88, 15.19) |

| Author/year | ES (95% CI) |
|-------------|-------------|
| Kidane et al., 2014 | 16.90 (13.06, 21.57) |
| Gebreslassie, 2015 | 14.10 (10.60, 18.27) |
| Senbeta, 2017 | 2.29 (0.90, 4.67) |
| Gebreyohanns et al., 2018 | 1.90 (0.84, 3.83) |
| Berhe et al., 2018 | 11.20 (7.15, 16.32) |
| Berhe et al., 2020 | 11.00 (8.05, 14.67) |
| Subtotal (I-squared = 94.8%, P ≤ 0.001) | 9.32 (4.44, 14.20) |

| Author/year | ES (95% CI) |
|-------------|-------------|
| Ayalew et al., 2008 | 35.30 (30.80, 40.12) |
| Subtotal (I-squared = 4%, P = -) | 35.30 (30.64, 39.96) |

| Author/year | ES (95% CI) |
|-------------|-------------|
| Mekonnen et al., 2014 | 9.60 (6.60, 13.38) |
| Aklilu et al., 2015 | 10.50 (6.20, 16.50) |
| Subtotal (I-squared = 0.0%, P ≤ 0.775) | 9.87 (7.04, 12.70) |

| Author/year | ES (95% CI) |
|-------------|-------------|
| Tigabu et al., 2010 | 26.60 (21.65, 32.24) |
| Gebretsadik, 2017 | 7.50 (5.12, 10.84) |
| Subtotal (I-squared = 97.4% P ≤ 0.001) | 16.91 (1.80, 35.63) |
| Overall (I-squared = 99.0%, P ≤ 0.001) | 10.03 (7.69, 12.38) |

Note: weights are from random effects analysis

Figure 4: The pooled prevalence of *G. lamblia* among study participants in Ethiopia.
was computed from ten studies [3, 17, 27–29, 31, 42, 46, 48, 50]. The pooled results showed that uneducated mothers, fathers, and children were 1.69 times more likely to have intestinal protozoan parasitic infections than those who were educated (OR: 1.69, 95% CI: 0.84-2.54) (S6).

Results from six studies revealed that the level of household income was strongly associated with HIPPIs [31, 33, 41, 42, 44]. People who had low household income were 1.64 times more likely to have intestinal protozoan parasitic infections than those who had higher family income (OR: 1.64, 95% CI: 0.96-2.32) (S7).
The pooled results of eleven studies [17, 27, 28, 30, 31, 38, 42, 46, 47, 50, 51] revealed that people who drink unprotected water were 3.33 times more likely to have intestinal protozoan parasitic infections than those who drink protected water (OR: 3.33, 95% CI: 1.30-5.36) (S8).

The pooled analysis of two studies conducted in Ethiopia [3, 35] showed that people who had the habit of playing with soil were 2.15 times more likely to have intestinal protozoan parasitic infections than those who did not (OR: 2.15, 95% CI: 1.01-3.29) (S9).

The pooled results of five studies [31, 45-47, 50] showed that family sizes were strongly associated with intestinal protozoan parasitic infection among people in Ethiopia. The likelihood of intestinal parasitic infection was 3.7 times higher among people with a family size of above 5 that those with low family sizes (OR: 3.7, 95% CI: 1.45-5.85) (S10).

4. Discussion

Human intestinal protozoan infections are the major IPIs and are the common causes of morbidity and mortality in Ethiopia [23]. Knowing the exact national pooled prevalence of HIPPIs is useful for policymakers. The pooled prevalence of HIPPIs in this systematic review and meta-analysis study was 25.01% (95% CI: 20.08-29.95). It was higher than studies conducted in Côte d’Ivoire (18.7%) [52], Tanzania (17.4%) [53], Saudi Arabia (18.7%) [54], and Qatar (5.93%) [55]. However, it was almost similar to the studies from Bulgaria (25.53%) [56], Spain (28%) [57], the Democratic Republic of São Tomé and Príncipe (28.6%) [58], and Iran (21%) [59].

The prevalence of HIPPIs in the present study was lower than that of Libya (85%) [14]; Shahura Health Center, Amhara region, Ethiopia (39.84%) [49]; Cambodia (53.9%) [58]; Senegal (32.6%) [60]; Thailand (37.8%) [61]; Palestine (39.21%) [62]; Ghana (42.9%) [63]; Sudan (54.2%) [64]; Tripoli, Senegal (56%) [65]; Kut city, Iraq (57.5%) [66]; Iraq (98.8%) [67]; Cameroon (74.3%) [68]; Malaysia (72.3%) [69]; Mexico (65%) [70]; Mexico (60%) [71]; and Burkina Faso (84.7%) [72]. The differences may be attributed to methodological, social, economic, demographic, hygienic, weather and climatic, environmental, and political factors.

The highest HIPPI prevalence was observed among patients (32.65%, 95% CI: 25.64-39.67) and schoolchildren (24.21%, 95% CI: 17.89-30.52) while the lowest prevalence was observed among rural dwellers (13.29%, 95% CI: 0.85-25.72) and preschool children (15.81%, 95% CI: 2.23-29.40). Parental care among preschool children may be the reason for their lower prevalence. But school-age children have higher prevalence due to their habit of playing with soil [3, 35]. The high prevalence of HIPPIs among patients might be due to their high susceptibility to protozoan parasites that might be associated with low immunity. Intestinal parasitic infections were more prevalent among the poor divisions of the population with poor handling of personal and environmental sanitation [46].

The trend of HIPPIs in Ethiopia from 2008 to 2012, 2013 to 2017, and 2018 to 2020 were 31.28% (95% CI: 12.78-49.77), 22.58% (95% CI: 17.52-27.64), and 25.30% (95% CI: 18.33-32.27), respectively. Accordingly, the prevalence of HIPPIs in the first ten years was reduced from 31.28% to 22.58%. However, it rose from 2018 to 2020 by close to 2.72%. This finding disagreed with the study done in Qatar in which HIPPI prevalence reduced from 2005 to 2008 (7.98%, 95% CI: 7.429-8.536), 2009 to 2011 (5.13%, 95% CI: 4.673-5.593), and 2012 to 2014 (4.89%, 95% CI: 4.488-5.286) [55]. The rise of HIPPIs from 2018 to 2020 in this study may be due to a lack of mass treatment, especially school deworming [73].

The pooled prevalence of G. lambia was 10.03% in this meta-analysis, which is in line with the studies conducted in Côte d’Ivoire (13.1%) [52], Tanzania (10.6%) [53], Ghana (12.2%) [63], Iraq (10.8%) [67], and Nepal (12.5%) [74]. However, it was lower than studies in Tripoli, Libya (28.5%) [14]; Bulgaria (62.05%) [56]; Spain (18%) [57]; Cambodia (31.5%) [58]; Senegal (20.4%) [60]; Sudan (22.9%) [64]; Mexico (24%) [70]; Burkina Faso (28.1%) [72]; Dhaka (17.6%) [75]; the Philippines (19.2%) [76]; and Turkey (47.97%) [77]. But, G. lambia prevalence (10.03%) in this study was much higher than that of Saudi Arabia (3%) [54], Thailand (4.2%) [61], Kenya (6.5%) [63], Iraq (4%) [66], Cameroon (3.3%) [68], Iran (1.7%) [59], Libya (4.9%) [78], Turkey (6.1%) [79], and Thailand (0.6%) [80]. The variations might be due to variations in the quality of drinking water sources and environmental conditions [81].

The pooled prevalence of E. histolytica/dispar was 14.09% in the present meta-analysis. It agrees with the reports from Pahang, Malaysia (18.5%) [69]; the Philippines (12.1%) [76]; and Karnataka, India (9%) [82]. However, the result of this study was higher than that of studies in Saudi Arabia (2%) [54], Iran (0.6%) [59], Thailand (0.73%) [61], Ghana (0.21%) [63], Cameroon (7.3%) [68], and Mexico (5%) [70]. In contrast, the results of the present study were lower than those of studies from Côte d’Ivoire (56%) [52]; Tanzania (28.5%) [53]; Sudan (31.2%) [64]; Kenya (23.9%) [65]; Kut city, Iraq (41%) [66]; Iraq (88%) [67]; Burkina Faso (66.5%) [72]; and Libya (21.14%) [78]. The variation might be due to the quality of food and water and the environmental condition of the different study localities. E. histolytica/dispar is an environmental contaminant of drinking water supply and food. It can be transmitted by drinking infected water and by consuming contaminated vegetables and food [81].

The pooled prevalence of Cryptosporidium species was 5.93%, which is higher than other studies from Saudi Arabia (3%) [54], Bulgaria (1.69%) [56], Spain (1%) [57], Iran (0.4%) [59], Senegal (0.3%) [60], Dhaka (0.5%) [75], Libya (0.8%) [78], and China (2.4%) [83]. The result of this meta-analysis was lower than that of studies conducted in Iraq (10.4%) [14], Ghana (8.5%) [63], Kenya (13%) [65], Iraq (12.5%) [66], Cameroon (44%) [68], and the Philippines (22%) [76]. The reason for the low prevalence of Cryptosporidium infection in Ethiopia might be associated with the types of laboratory diagnostic procedures. About 84% studies included in this meta-analysis did not use appropriate methods for detecting opportunistic parasites such as Cryptosporidium.

This meta-analysis and systematic review study showed that there was a clear variation in the prevalence of HIPPIs in Ethiopia. The highest pooled prevalence was observed...
from Dire Dawa while the lowest prevalence was obtained from the Oromia region. The potential justification for this difference might be due to the peculiarity in sociodemographic, environmental, geographical, and behavioral characteristics. Similar observations were reported from Nepal [84].

The odds of HIPPI occurrence was 1.7 times higher among groups who did not have regular fingernail trimming and cleanliness habits compared to their counterparts. This finding is supported by the studies conducted in Sri Lanka [13] and Nepal [74]. It is known that unclean fingernails may contain cysts of protozoan parasites that lead to higher infection.

The habit of handwashing was significantly associated with the prevalence of HIPPIs in Ethiopia. The odds of having HIPPIs among people who did not wash their hands after defecation was about 2.8-fold higher than that among people who used to wash their hands regularly. This finding is opposed to the studies conducted in Sudan [64] and Nepal [74]. This might be due to fecal-oral contamination through unwashed hands.

Age (children up to 14 years) was significantly associated with the prevalence of intestinal protozoan parasitic infections. The result was supported by the studies conducted in Iran [59], Palestine [62], Ghana [63], Sudan [64], Cameroon [68], Libya [78], and Karachi [85]. This might be because children have weak immunity than adults. Their complex nutritional requirements and less developed immune systems make children the principal sufferers of the intestinal parasitic infections [1].

The habit of eating raw, unwashed, contaminated, and leftover fruits and vegetables was significantly associated with intestinal protozoan parasitic infections. This was supported by the studies done in Sri Lanka [13] and Tripoli, Libya [14]. This is because raw, unwashed, contaminated, and leftover fruits and vegetables carry intestinal protozoan parasites [81].

Families with low-level education were 1.3 times more likely to have HIPPIs than educated families. This result was supported by studies done in Iran [59], Cameroon [68], Mexico [70], and Nepal [74]. The reason may be uneducated people lack the necessary knowledge and practices towards the transmission and prevention of HIPPIs [70].

In this meta-analysis, drinking of unprotected water was significantly associated with the occurrence of HIPPIs in Ethiopia. The people who drink unprotected water were 3.3 times more likely to have intestinal protozoan parasitic infections than those who use protected water. This finding was in line with the studies done in Ethiopia [46], Sudan [64], Cameroon [68], Mexico [71], Turkey [77], and China [83]. This is because unprotected water would have a pool of intestinal protozoan parasites and can be a source of infection.

Water is one of the important vehicles for pathogen dissemination [86]. *E. histolytica/dispar*, *Cryptosporidium*, and *G. lamblia* are environmental contaminants of drinking water supplies [82].

This meta-analysis showed that open field defecation was significantly associated with the presence of human intestinal protozoan parasitic infections. People who practiced open field defecation were 2.74 times more likely to have intestinal protozoan parasitic infections than their counterparts. The result of this study was in accordance with the study done in Ethiopia [46], Mexico [70], and South India [87]. In developing countries, poor hygiene and the use of untreated human feces are important factors that contribute to the contamination of food and water. Due to this, *E. histolytica*, *G. lamblia*, and *Cryptosporidium* spp. could be transmitted to humans [88]. Intestinal parasitic infections also occur via contaminated material such as earth, water, uncooked, or cross-contaminated food that has been in contact with the feces of an infected individual or animal [89].

People who had poor levels of income were 1.64 times more likely to have intestinal protozoan parasitic infections than their counterparts. This might be due to lack of treatment, medication, and quality food and water and poor living conditions among the people who had poor economic levels. This result is in agreement with the study from Mexico [70]. On the contrary, this finding was opposed to the study done in Gondar, Ethiopia; the level of income is not associated with the prevalence of intestinal parasitic infections [41].

The people who had the habit of playing with soil were about 2-fold more likely to have HIPPIs than their counterparts. The study was in accordance with the study conducted in North Shewa, Ethiopia [3]. This is because the soil contains eggs and cysts of protozoan intestinal parasites which could contaminate food and water [5].

The people who had a large family size (>5) were nearly 4-fold more likely to have intestinal protozoan parasitic infections than those who have a small family size. This might be because a large family size would increase the chance of more contact with each other and could be a source of transmission of protozoan infections [2]. The outcome was in line with studies done in Ethiopia [46] and Turkey [77].

5. Limitations of the Study

This meta-analysis and systematic review study produced a lot of valuable data about intestinal parasites in Ethiopia, but it has also several limitations. The articles included in this meta-analysis were not derived from all regions (information about HIPPIs was lacking from Afar, Gambela, Somali, and Harari regions). Besides, the information used in this meta-analysis was not uniformly distributed in the regions included in this meta-analysis. Therefore, the result may not fully represent the national prevalence of intestinal parasitic infection.

6. Conclusion

The pooled prevalence of intestinal protozoan parasitic infections according to this review was found to be 25.01%. There was a clear difference in the prevalence of HIPPIs across regions in the country. Fingernail trimming, handwashing habits, age, open field defecation, the habit of eating raw fruits and vegetables, level of family education, levels of income, source of drinking water, playing with soil, and family size were significantly associated with the prevalence of
intestinal protozoan parasitic infections. This study highlights the importance of proper health education on personal hygiene, handwashing practice, open field defecation, handling of food, selections of living rooms of animals to prevent animal contact, and food safety. Therefore, all stakeholders should give proper attention to increasing awareness of the community and proper treatments of infected patients.

Abbreviations

AOR: Adjusted odds ratio
CDC: Center for Disease Controlling program
CI: Confidence interval
DALYs: Disability-adjusted life years
GRADE: Grading of Recommendations Assessment, Development and Evaluation
HIPPIs: Human intestinal protozoan parasitic infections
HIPPs: Human intestinal protozoan parasites
IPIs: Intestinal parasitic infections
OR: Odds ratio
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
spp.: Species
WHO: World Health Organization.

Data Availability

All related data has been presented within the manuscript and on supplementary data. The dataset supporting the conclusions of this article is available from the authors on request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors’ Contributions

DT developed the draft proposal under the supervision of DD. TH guided the statistical analysis. All authors (DT, DD, and TH) critically reviewed, provided substantive feedback, 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.

Supplementary Materials

S1: the pooled odds ratio of the association between fingernail trimming and cleanness and HIPPIs in Ethiopia. S2: the pooled odds ratio of the association between handwashing habits and HIPPIs in Ethiopia. S3: the pooled odds ratio of the association between age and HIPPIs in Ethiopia. S4: the pooled odds ratio of the association between open field defecation habit and HIPPIs in Ethiopia. S5: the pooled odds ratio of the association between eating raw, undercooked, contaminated, and leftover food and HIPPIs in Ethiopia. S6: the pooled odds ratio of the association between the level of education and HIPPIs in Ethiopia. S7: the pooled odds ratio of the association between the level of family income and HIPPIs in Ethiopia. S8: the pooled odds ratio of the association between the unprotected drinking water sources and HIPPIs in Ethiopia. S9: the pooled odds ratio of the association between playing with soil and HIPPIs in Ethiopia. S10: the pooled odds ratio of the association between the number of family size and HIPPIs in Ethiopia.

( Supplementary Materials)

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