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ORIGINAL RESEARCH

Childhood Intestinal Parasitic Reinfection, Sanitation and Hygiene Practice in Eastern Ethiopia: Case Control Study

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Background: The recurrence of intestinal parasitic infections (IPIs) can lead to different problems that can be transferred from generation to generation. Sanitation and hygienic practices have vital role in the parasitic reinfection. In poor hygienic and sanitation condition children may live in a continuous cycle of infection and reinfection.

Objective: To assess childhood IP reinfection and its association with sanitation and hygienic practice in eastern Ethiopia.

Methods: A population-based case-control design was used in this study. Data were collected from 75 reinfected cases and 147 unmatched controls. Fecal specimens were observed for parasites using direct smear and formol ether techniques. Epi-Info and SPSS (the statistical package for social science) were used for data entry and analysis, respectively. Logistic regression analysis was conducted to identify significant associations ($P<0.05$) between variables.

Results: The overall IP reinfection rate within 24 weeks after treatment was 33.8% (75/222), with a 95% CI=27.7%–40.5%. The frequency of intestinal protozoa was 18%, and for helminths was 15.8%. Children who swam in a polluted water had 3.7 times greater odds of IP reinfection than children who did not swim ($P = 0.01$, 95% CI: 1.4–10.0). Children who regularly bathed in streams and children who bathed both at home and in streams were found to have 12.6 times and 5.8 times higher odds of IP reinfection than children who bathed regularly at home (P=0.002, 95% CI:2.5–64.8) and (P = 0.042, 95% CI:1.1–31.3), respectively. Children in households that owned domestic animals had 4.5 times higher odds of IP reinfection than the reference group (P = 0.013, 95% CI: 1.3–12.5).

Conclusion: IP reinfection rates were significantly associated with habits of swimming in a polluted water, places of bathing, and ownership of domestic animals. Therefore, efforts should be made considering such factors to minimize IP reinfection in the area.

Keywords: Ethiopia, hygiene, reinfection, sanitation

Introduction

Even though human parasitic infections are avoidable NTD,[1] they are nonetheless widespread in developing nations like Ethiopia. According to Chelkeba,52% of school-age children and 30% preschool-aged children were infected with IP.[2] Among primary school children the pooled prevalence of IPIs was determined to be 46.09% and Entamoeba spp (16.11%), Ascaris lumbricoides (13.98), Hookworm (12.51%) and Giardia lamblia (9.98%) are among the most prevalent parasitic infections according to a systematic review and meta-analysis study in Ethiopia.[3]

Helminth infections that persist over time can result in anorexia, diarrhea, and malabsorption, increasing the risk of anemia, growth retardation, and compromised cognitive development.[4] Anemia and growth retardation are caused by protozoan infections, which also cause nutritional depletion and weakened immunity.[5] *G. intestinalis* infection can result in both acute and chronic diarrhea.[6,7] Serious health and social issues associated with parasitic infection include malabsorption, diarrhea, bleeding, stunting, wasting, cognitive decline, and diminished job ability. These issues place a significant financial strain on communities.[8–10]

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IPIs are linked to environmental fecal pollution, inadequate hygienic standards, and a dearth of sanitation services.[11] Feces in the environment can be removed with the use of sanitary facilities and appropriate waste disposal. Cleaning-related behaviors, like washing hands with soap and water, are included in hygiene.[12,13] Children's poor hygiene practices (HP) can have a big social and economic impact. Some of these effects include missing school, spreading infectious diseases to other people, and costing parents and guardians lost workdays.[14] The most crucial element in lowering infectious disease rates is adequate HP.[15] Children may live in a continuous cycle of infection and reinfection if there are inadequate hygienic practices and basic sanitation conditions.[16]

Recurring of parasitic infection can have negative effects that are contagious and can be inherited by future generations, resulting in a cycle of poverty and ill health.[17] In environments with inadequate sanitation, reinfection is typically linked to high levels of environmental contamination by infectious cysts or oocytes.[18] *Schistosoma* and STH have been the subject of the majority of research on the reinfection of parasitic infections in Ethiopia.[18–20] A pooled prevalence of 25.01% for human intestinal protozoan parasitic infection was reported by Dires.[21] Thus, the aim of this study was to assess the association between intestinal parasite reinfection in children and related factors, such as sanitation and hygiene.

Methods and Materials

Study Area

This study was conducted in Dire Dawa, one of Ethiopia's two administrative cities. Dire Dawa City is reachable by road, train, and airplane. The region is delimited to the north by Somalia region and to the south by Oromiya Regional State. The area is located 500 kilometers east of the capital city of the country. Dire Dawa covers 155,861 hectares in total, of which 152,937 ha (98%) are in rural areas. Nine urban and 38 rural kebeles are found in the region.

Study Design, Study Population, Period

The present research is a case-control study, and the study population was selected from the baseline survey. Children with a positive result for IPIs during the baseline survey[22] and those children with a negative result after 2–3 weeks of treatment were followed to investigate factors associated with intestinal parasitic reinfections, including sanitation and hygienic factors, from May to October 2021.

Inclusion and Exclusion Criteria

Inclusion Criteria

Study subjects with positive results for IPIs in the baseline study, who became free of this infection after treatment, and who were able to give stool samples 24 weeks after treatment.

Exclusion Criteria

Participants who had taken antiparasitic drugs within the follow-up period and children who were unwilling to participate in the follow-up study.

Sample Size

Open-Epi version 2.3 (open-source epidemiologic software) for public health was used to determine the sample size. In the previous study, the variable that allowed the largest sample size was considered for this study. Therefore, the sample size was estimated using the age of the children as a predictor for reinfection of intestinal parasites, with 39% of controls and 19.02% of cases.[23] We used a 2-tailed test with a 95% CI and 80% power. Ten percent of the non-response rate was also considered, and a ratio of case/control = 2. The total sample sizes for cases and controls were 77 and 153, respectively.

Sampling Technique

Seven hundred seventy-eight (778) children participated in the baseline survey and based on their stool result only children with a positive stool result for IPIs (262) were selected.[22] And these 262 positive children were treated and examined for IPIs after 2–3 weeks of treatment. Again, based on their stool examination result, 230 children with a negative results became candidates to be followed up for 24 weeks. After 24 weeks of follow-up,8 children fail to participate in providing information for the questionnaire. So, in this study totally 222 children were participated both in providing stool sample and questionnaire-based information. Of these 222 children 75 of them were cases (reinfected children) and 147 children remained with negative results (controls) during stool examination.

Study Variables

Dependent Variable

Intestinal parasite reinfection (reinfected(cases) or non-reinfected (controls) was used as a dependent variable in this study.

Independent Variable

Several possible determinants associated with intestinal parasitic reinfections were investigated in this study. Independent variables were in the form of socio-demographic factors like sex, age, level of education, parental occupation; habits like swimming in a polluted water, bathing place; sanitary condition include latrine ownership, utilization and latrine cleanliness, child feces disposal place, defecation place, solid waste management; hygienic practice such as practice of hand washing at critical times and using of agents during hand wash were considered in the study.

Data Collection Methods

Demographic information, sanitation, and hygienic-related data were collected by using pretested questionnaires through face-to-face interviews by six trained nurses. While laboratory technicians gathered and processed the stool sample from each participant, Questionnaires were prepared in English, then interpreted into “Amharic” and ‘Afaan Oromoo,’ finally back into English to check for reliability and to address the participants in their mother tongue.

Fecal Sample Gathering and Examination

Two hundred twenty-two (222) study participants provided fecal samples and questionnaire-based data. The study participants received instructions on how to bring stool samples. Laboratory technicians collected the stool sample from participants. Following collection, a piece of each fecal sample was processed under a direct microscope using the wet smear method.[24] The remainder of each fecal sample was preserved with 10% formalin and taken to the Dire Dawa Dil Chora Hospital laboratory in an ice box (kept at 2°C–8°C) in order to run the formol-ether concentration technique and be tested for IPI detection.

On the field for direct wet mount method, about 0.05g of stool was mixed with a few drops of normal saline, placed on a clean slide, and covered with a cover slip. And after this preparation, the slide was observed for the presence of IPIs.

For formo-ether concentration technique a pea-sized amount of stool was emulsified in4ml of 10% formol water for examination using the formol-ether test. The mixture was manually shaken after 4 milliliters of 10% v/v formol water added. After sieving the emulsified stool was sieved, and the suspension was transferred to a centrifuge tube, where 4 milliliters of diethyl ether were added. Following one minute of mixing, the material was centrifuged for 1 minute at 750 to 1000g. Centrifuging caused the parasite to settle at the tube’s bottom, and the stool debris was extracted from the space between the formol and ether layers. Next, from each processed stool specimen, slide smears were made, and the Olympus microscope was used to look for intestinal parasites using 10× and 40× objectives.[24]

Data Quality Control

A structured and pretested questionnaire was prepared in English, translated to “Amharic” and “Afaan Oromoo”, and again retranslated to English to check for any inconsistencies, mismatches of meanings, and concepts. The collected questionnaires were checked for accuracy and clarity by the supervisors and principal investigator on a daily basis. Instruments and reagents were also checked for consistency and replicability before any test was started.

Data Entry and Statistical Analysis

Data was entered using EPI-Info version 3.5.3. The imported data (from EPI-Info) was checked, cleaned, and analyzed using the statistical package for social science (SPSS) version 23. Frequencies and percentages were calculated using descriptive statistics. Chi-square(x^2) test was executed to verify the possible association between dependent and independent variables. Logistic regression was used to compute the strength of association between the prevalence of reinfection and risk factors via odds ratio. Result was considered significant when the *p*-value was below 0.05 after multivariate analysis. Finally, results were presented using text, tables, and figures.

Results

Characteristics of the Study Participants

A total number of 222 under 14 children were enrolled in the study (75 reinfected cases and 147 controls). In the present study, there were 49 (65.3%) male and 26 (34.7%) female reinfected subjects. While 90 (61.2%) male and 57 (38.8%) female participants were from non-reinfected children. A majority (56.0%) of the participants in the cases group were in the age range of 5–9 years, and a higher portion (49.0%) of the control group was in the age range of 10–14 years. The proportion of children who have a swimming habit in a polluted water was 77.3% in cases, and the proportion of children with this behavior in non-reinfected subjects was 53.7%. Of the total 13 children who bathed in both places, sometimes at home and other times in the streams, 10 were from the reinfected group, and only 3 were from the control group. Eighty-four percent of the households in the reinfected group had domestic animals; 78.2% of those in the non-reinfected group owned domestic animals (Table 1).

Table 1 General Characteristics of Reinfected Children (n=75) and Non-Reinfected Children (n=147) in the Eastern Ethiopia, 2021

Variables	Participants Stool Results		
	Cases N (%)	Controls N (%)	Total (%)
Child sex			
Male	49(65.3)	90(61.2)	139(62.6)
Female	26(34.7)	57(38.8)	83(37.4)
Age of children in years			
1–4	1(1.3)	5(3.4)	6(2.7)
5 –9	42(56.0)	70(47.6)	112(50.5)
10–14	32(42.7)	72(49.0)	104(46.8)
Mother's education			
Illiterate	51(68.0)	97(66.0)	148(66.7)
Primary	24(32.0)	50(34.0)	74(33.3)
Father's education			
Illiterate	28(37.3)	45(30.6)	73(32.9)
Primary	39(52.0)	91(61.9)	130(58.6)
Secondary	8(10.7)	11(7.5)	19(8.6)

(*Continued*)

Table 1 (Continued).

Variables	Participants Stool Results		
	Cases N (%)	**Controls N (%)**	**Total (%)**
Mother's occupation			
Housewife	41(54.7)	61(41.5)	102(45.9)
Farmer	16(21.3)	68(46.3)	84(37.8)
Merchant	18(24.0)	18(12.2)	36(16.2)
Knowledge of IP acquisition			
No	46(61.3)	70(47.6)	116(52.3)
Yes	29(38.7)	77(52.4)	106(47.7)
Knowledge of IP symptom			
No	60(80.0)	120(81.6)	180(81.1)
Yes	15(20.0)	27(18.4)	42(18.9)
Do you have currently symptom?			
No	56(74.7)	115(78.2)	171(77.0)
Yes	19(25.3)	32(21.8)	51(23.0)
Knowledge of IPI complication			
No	74(98.7)	147(100.0)	221(99.5)
Yes	1(1.3)	0(0.0)	1(0.5)
Swimming in a polluted water			
No	17(22.7)	68(46.3)	85(38.3)
Yes	58(77.3)	79(53.7)	137(61.7)
Child's bathing place			
Home	36(48)	74(50.3)	110(49.5)
Local streams and reservoirs	29(38.6)	70(47.6)	99(44.6)
Both	10(13.3)	3(2.0)	13(5.9)
Do you have domestic animal?			
No	12(16)	32(21.8)	44(19.8)
Yes	63(84)	115(78.2)	178(80.2)

Sanitation Associated with Childhood IP Reinfection

Of the assessed sanitary factors, latrine ownership and child defecation place were factors crudely associated with intestinal parasitic reinfection. The crude OR for the association between latrine ownership and place of child defecation with childhood IP reinfection was 2.29 (1.2–4.4) and 2.5 (1.3–4.8), respectively. Among the households of the 75 children in the reinfected group, 24 (32%) and 17% of those in the non-reinfected group had no latrine. This difference was statistically significant (P = 0.013). Of the 51 households with infected children, 47 (92.2%) had unclean latrines, significantly more than in households with non-reinfected children (86.9%, *P* = 0.340). Open field defecation was higher in the reinfected group than the non-reinfected group (33.3% vs 16.3%), and this difference was statistically significant (P = 0.006) (Table 2).

Table 2 Bi-Variable Association of Sanitation with Intestinal Parasitic Reinfected Cases (n=75) and Controls (N= 147) in the Eastern Ethiopia, 2021

Variable	Stool Result		Unadjusted OR (95% CI)	p-value
Latrine ownership	**Cases N (%)**	**Controls N (%)**		
No latrine	24(32.0)	25(17.0)	2.3(1.2–4.4)	0.013
Have latrine	51(68.0)	122(83.0)	1	
Latrine utilization				
Sometimes	12(23.5)	17(13.9)	1.9(0.8–4.3)	0.137
Always	39(76.5)	105(86.1)	1	
Latrine cleanliness				
No	47(92.2)	106(86.9)	1.77(0.6–5.6)	0.340
Yes	4(7.8)	16(13.1)	1	
Child feces disposal				
Safe		4(80)	NA	
Unsafe	1(100)	1(20)		
Child defecation place				
Open field	25(33.3)	24(16.3)	2.51(1.3–4.8)	0.006
Mother take care	1(1.3)	5(3.4)	0.48(0.05–4.2)	0.57
Use latrine	49(65.3)	118(80.3)	1	
Solid waste management				
Buried in one place	9(12.0)	31(21.1)	0.46(0.2–1.3)	0.152
Collected by waste collectors	29(38.7)	41(27.9)	1.12(0.5–2.7)	0.806
Discarded in open field	25(33.3)	56(38.1)	0.71(0.3–1.7)	0.439
Burned	12(16.0)	19(12.9)	1	

Abbreviation: NA, not applicable.

Hygiene Associated with Childhood IP Reinfection

Table 3 shows the crude relationship between hygiene practices and IP reinfection. Among the hygienic behaviors, hand washing only with water after toilet use was significantly associated with intestinal parasitic reinfection in the bi-variable analysis (OR 3.4 (1.9–6.1)). Forty-nine (66.2%) of the cases and 36.6% of the controls practiced hand washing only with water after toilet use, and the difference was statistically significant (P = 0.000). In the control group, of the 6 mothers who washed their hands after child feces care, two used soap or ashes during hand washing, but this practice was absent among the cases. In both groups, all mothers practiced hand washing before feeding their children, but none of them used cleaning agents like soap or ashes. The hygienic practice of hand washing before cooking was similar in both groups, but there was a difference in using agents during hand washing. The use of soap or ashes during hand washing before cooking among cases and the control group was one-third (35.6%) of mothers of cases, but significantly more mothers of the controls (47.6%, P = 0.094) used soap. Hand washing before eating was practiced by all children in both groups, whereas the use of soap or ashes during the practice was 35.6% and 64.4% in the cases and control groups, respectively (P = 0.607).

Table 3 Univariate Logistic Regression Analysis for the Association of Hand Hygiene Practice with Reinfected Cases (n = 75) and Controls (n = 147) in Eastern Ethiopia 2021

Hand Wash After Defecation	IP Reinfection		Unadjusted OR (95% CI)	P-value
	Cases N (%)	Controls N (%)		
No	1(1.3)	2(1.4)	0.97(0.1–10.9)	0.976
Yes	74(98.7)	145(98.6)	1	
Hand wash with				
Water only	49(66.2)	53(36.6)	3.4(1.9–6.1)	0.000
Water/soap/ash	25(33.8)	92(63.4)	1	
Parent hand wash after child feces care				
No			NA	
Yes	1(100)	5(100)		
Hand wash with				
Water only	1(100)	3(60.0)	NA	
Soap/ash		2(40.0)		
Hand wash before cooking				
No	2(2.7)	2(1.4)	1.9(0.3–14.4)	0.529
Yes	73(97.3)	145(98.6)	1	
Hand wash with				
Water	47(64.4)	76(52.4)	1.6(0.9–2.9)	0.094
Water/soap/ash	26(35.6)	69(47.6)	1	
Mother hand wash before child feed				
No			NA	
Yes	1(100)	5(100)		
Hand wash with				
Water	1(100)	5(100)	NA	
Water/soap/ash				
Hand wash style after caring of animal waste				
No			NA	
Yes	47(100)	115(100)	1	
Hand wash with				
Water	39(83)	97(84.3)	1.2(0.4–2.3)	0 0.819
Use soap/ash	8(17)	18(15.7)	1	
Child hand wash before eat				
No			NA	
Yes	74(100)	142(100)		

(*Continued*)

Table 3 (Continued).

Hand Wash After Defecation	IP Reinfection		Unadjusted OR (95% CI)	P-value
	Cases N (%)	Controls N (%)		
Hand wash with				
Water only	27(32.1)	57(67.9)	0.9(0.5–1.5)	0.607
Using soap/ash	47(35.6)	85(64.4)	1	

Abbreviation: NA, not applicable.

Detected Parasites in Reinfected Children After 6 Months Follow Up Period

The identified IPs in reinfected children after 6 months of follow-up were *Giardia intestinalis* (40), *Hymenolepis nana* (27), *Schistosoma mansoni* (6), and *Enterobius vermicularis* (2) Protozoan reinfection was 18% and helminthic reinfections were 15.8% (Figure 1).

Factors Associated with Intestinal Parasitic Reinfection

In the bivariable analysis, mother's occupation, habit of swimming in a polluted water, place of child bathing, latrine ownership, place of child defecation, washing hands after defecation using water only, and owning domestic animals were factors associated with childhood IP reinfection.

In the multivariable analysis, children who have swimming practice in a polluted water were 2.9 times more likely to be exposed to IP reinfection when compared to children without this practice. Reinfection of IP among subjects who regularly bathed in local ponds or streams and children who took baths in both places (some time at home and another time in the local ponds or stream) was 12.6 and 5.8 times more likely to have IP reinfection as compared with children who took baths at home, respectively. Reinfection of IP was 4.2 times greater in the study subjects from households that own domestic animals than in children from households without domestic animal existence (Table 4).

Discussion

Of the total 33.8% (75) of reinfected cases, 18% (40) and 15.8% (35) were protozoan and helminthic infections, respectively. A study in Cote d'ivoire also reported higher protozoan (70.39%) than helminthic reinfections (7.79) after a 5-month follow-up.[25] Similarly the study in Kenya reported that in the intervention group at the endline the prevalence of protozoan infection was higher than helminths.[26] A study in north-western Ethiopia found 36.3% of soil-transmitted helminths (STH) reinfection one year after treatment,[27] and another study in southern Ethiopia reported 36.8% of STH reinfection within 12 weeks after treatment.[28] In the present study, *S. mansoni* was among the identified IPs in reinfected children accounting for 2.7%. In northwest Ethiopian study 13.9% reinfected cases of this infection were stated.[20] Another study from northern Minas Gerais State (Brazil) reported 21.9% of *S. mansoni* reinfection rate

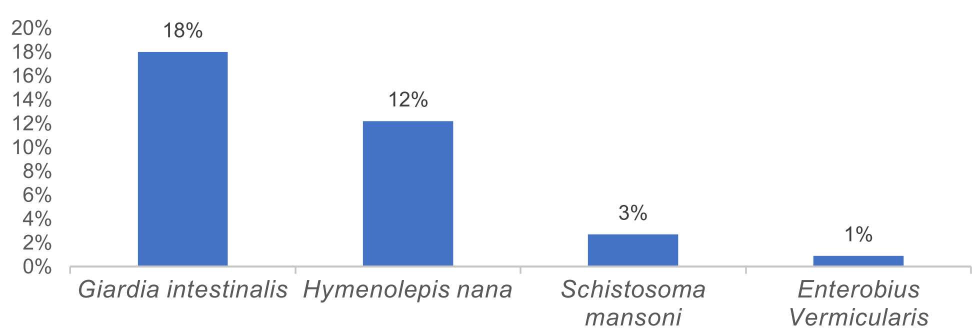

Figure 1 Percentage of intestinal parasites identified in under 14 children six months posttreatment in the easter Ethiopia, 2021.

Table 4 Unadjusted and Adjusted Analysis for Factors Associated with IP Reinfection Among Children Under-14 Years of Age in Eastern Ethiopia, 2021

Variables	IP Reinfections		Unadjusted OR (95% CI)	AOR (95% CI)	P-value
	Cases (%)	Non-Reinfected (Controls (%)			
Habit of Swimming in polluted water					
Yes	58(77.3)	79(53.7)	2.9(1.6–5.5)	3.7(1.4–10.0)	0.01
No	17(22.6)	68(46.3)	1	1	
Child bathing place					
Home	36(48.0)	74(50.3)	1	1	
Local ponds/ river	29(38.7)	70(47.6)	0.9(0.5–1.5)	12.6(2.5–64.8)	0.002
Both	10(13.3)	3(2.0)	6.9(1.8–26.0)	5.8(1.1–31.3)	0.042
Domestic animal existence					
Yes	63(84.0)	115(78.2)	1.5(0.7–3.0)	4.2(1.3–12.5)	0.013
No	12(16.0)	32(21.8)	1	1	

after one year treatment.[29] The variation in reinfection rate could be attributed with geographical location, follow up period or the resident's sanitation and hygienic behavior.

In the current study *G. intestinal* was the only and most prevalent parasite unlike that of research conducted in northwest Ethiopia on Effects of WASH education on childhood intestinal parasitic infections which indicated A. lumbricid as the most prevalent parasitic infection after a year of intervention.[30] This could be due to differences in the study design. The current study used case-control design while the study from northwest Ethiopia used uncontrolled before and after intervention. So, the intervention measures might bring the difference. Also, the deworming program may not target the protozoan group and may result the infection to be prevalent in this study. Another reason for the divergence might be participants age difference, geographical location, sanitary and hygienic practice dissimilarity.

Swimming practice in a polluted water was greater in the cases (77.3%) than in the controls (53.7%). And the current study result showed that the odds of IP reinfection were 3.7 times higher for children who have swimming practice in a polluted water when compared to the reference group (children without swimming practices), with a significant association ($P = 0.01$). Likewise, the study conducted in north-east Ethiopia showed a strong and significant association (P=0.00) between swimming practice and IPI.[31] In addition, the study in Rama town indicated that higher prevalence of IPs (3.1) was found among school-age children who have swimming habit in a contaminated water bodies than their counterparts with a significant association (P=0.021).[32] Another systematic and meta-analysis study revealed that swimming in rivers increase the risk to contract intestinal parasitic infection by 1.9 odds with significant association.[33] Unhealthy lifestyles might aid the intestinal parasites to be transmitted and reoccur.

Infection could also be contracted by bathing in contaminated water. Among cases those children who bathed sometimes in local ponds or river and another time at home were 13.3% while the percentile for non-reinfected children with this trend was only 2%. The odds of reinfection of intestinal parasites were 12.6 times higher in children who bathed in local streams or ponds and 5.8 times higher in children who bathed sometimes at home and other times in local streams or ponds than in children who bathed regularly at home, with significant statistics. The result from patients in Jimma revealed source of water for bathing was significant factors ($p < 0.05$) for intestinal parasitic infection.[34] This could be attributed to the fact that water bodies found in areas with open field defecation practice and poor sanitation conditions are susceptible to contamination, and this situation creates a good circumstance for IP reinfection.

Contracting parasites may take place through several routes, including close contact with pets. Eighty-four percent of the children in the case group were from families that own domestic animals. This may increase their contact with animals during animal care and other different activities, which makes them vulnerable to contract the infection from infected animals. The odds of IP reinfection were 4.2-fold higher among children from households that had domestic animals than their counterparts. A study in Iran also found a significant association between protozoan infection and contact with animals (P= 0.001).[35] A comparative cross-sectional study in Ethiopia reported that playing with domestic animals was significantly associated with protozoan infections.[36] Also, a study in Cameron showed a significant association of IPIs with domestic animals.[37] A comparative cross-sectional study in Algeria indicated that contact with animals was the key risk factor for transmission of protozoan in symptomatic and asymptomatic subjects.[38] The study in Burkina Faso also indicated a significant association (P=0.008) between domestic animals roaming freely within households compared to their counterpart and the prevalence of G. intestinalis.[39]

Conclusion and Recommendation

IP reinfection rates in children showed variation based on swimming habit, place of bathing, and ownership of domestic animals. So, we conclude that efforts that consider such risks are mandatory to minimize IP reinfection and limit its impact on public health in the region. Increasing community health awareness through effective health education in schools, media or other locally available methods is of paramount importance. Furthermore, ensuring the availability of sanitary places should be strengthened as a measurement to control the reinfection of intestinal parasites.

Study Limitations

This study had a few limitations. For stool examination, only wet mount preparation and formal ether concentration techniques were used rather than molecular methods due to a shortage of resources. Another limitation was that infection intensity and drug efficacy were not considered.

Data Sharing Statement

All relevant data are included in the paper.

Ethical Consideration

Ethical clearance was obtained from the Ethiopian Institute of Water Resources (EIWR) at Addis Ababa University (AAU) Assigned No: EIWR/135/08116. A support letter was obtained from the regional health bureau to facilitate cooperation in the study area. Official permission was obtained after Kebele leaders were contacted. All parents and guardians clearly explained the objective of the study, and written informed consent was obtained from each parent or guardian of each child. Positive children for IPIs were treated according to the national guidelines. This study adhered to the Declaration of Helsinki's ethical standards.

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Disclosure

The authors declare no conflicts of interest in this work.

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