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Original Article

Prevalence and Associated Risk Factors of Intestinal Parasitic Infections in HIV-infected Individuals at Enchini Hospital, West Shewa Zone of Oromia , Central Ethiopia

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Abstract
Background: *Little attention has been given to the prevalence of intestinal parasitic infections (IPIs) among HIV/AIDS patients in various regions of Ethiopia. This study aimed to determine the prevalence of IPIs and associated risk factors in individuals attending the antiretroviral therapy (ART) unit at Enchini Hospital in Ethiopia.*
Methods: *A cross-sectional study was conducted in 2020. Wet mount, formol-ether sedimentation, and modified Ziehl-Neelson techniques were used to examine stool samples collected from 222 HIV/AIDS patients. A pretested questionnaire was used to collect data on socioeconomic characteristics and risk factors for IPIs.*
Results: *The overall prevalence of IPIs among HIV/AIDS patients in the study area was 34.2% (76/222) with 95% CI (27.9%-40.5%).The prevalence of IPIs was found to be significantly higher (P<0.001) in pre-ART 46.4% (51/110) than on-ART 22.3% (25/112). Entameoba histolytica / dispar 28 (12.6%), Cryptosporidium parvum 12 (5.4%) and Isospora belli 9 (4.1%) were the most common IPIs identified in the study. Living in rural areas (Adjusted odd ratio (AOR)=6.23,95% CI= 1.70-22.67), not taking antiretroviral therapy (AOR=4.14,95% CI=1.49 - 11.35), a monthly income of ≤1500 Ethiopian birr (AOR=32.06, 95% CI=4.76-215.80), the use of river water for drinking purposes (AOR=18.04, 95% CI=5.05-64.43) and CD4 count <200 cells/µL (AOR=76.02, 95% CI=10.19-566.72) were significantly associated with IPIs.*
Conclusions: *This study showed that IPIs are common among HIV/AIDS patients at Enchini Hospital and are associated with factors such as income, hand-washing habits, ART status, and lower CD4 counts. To significantly improve the quality of life for these patients, we must strongly enhance public health measures and ensure unwavering adherence to ART.*

Keywords: *ART, Ethiopia, HIV/AIDS, Intestinal parasites, Prevalence, Risk factor.*
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Introduction

Human immune deficiency virus (HIV) is a major public health problem in the world [1]. In 2019, about 38 million people worldwide were living with HIV, and more than one million died as a result of HIV/AIDS-related complications and diseases, with Sub-Saharan Africa (SSA) accounting for approximately 69% of those who died.[2,3]. Individuals with HIV/AIDS are more vulnerable to intestinal parasitic infections (IPIs) due to their compromised immune systems [4].

IPIs remain a significant global public health problem, with an estimated 3.5 billion people affected worldwide [1, 2]. In sub Saharan Africa (SSA), it is estimated that up to 250 million people are infected with at least one species of intestinal parasite [4].The most common IPIs worldwide are trichuriasis, amoebiasis, ascariasis, and hookworm [5-7]. Coccidia (*Cryptosporidium parvum* (*C. parvum*), *Isospora belli* (*I. belli*), and *Cyclospora* sp.) are the most frequent parasites in HIV-positive people [5].

Combination antiretroviral therapy (cART) reduces the presence of opportunistic parasites in HIV/AIDS patients by improving survival rates and reducing the occurrence of opportunistic infections. This is achieved by lowering the viral load and increasing the number of CD4 cells [10]. For example, *Cryptosporidiu*m species infections were more prevalent in patients who had not received ART and were significantly associated with lower CD4 counts (<200 cells/mm3) [14].

Several studies conducted in health facilities across different regions of Ethiopia have reported varying prevalence of IPIs. For example, the prevalence of IPIs among HIV patients was 80.3% at Bahadar Dar Gambi Clinic [8], 56.6% at Dessie Hospital [9], 35.9% at Butajita General Hospital [10], 33.7% at Hiwot Fana Specialized Hospital [11], 29.1% at Gondar Hospital [12], 25.3% at Debretabor General Hospital [13], 28.2% at Arbaminch Hospital [14] and 13.9% at Kombolcha Health Center [15].

There are several factors that contribute to the high prevalence of IPIs among HIV patients in Ethiopia. These factors include low living conditions, inadequate or absent clean water supply, low socioeconomic status, insufficient environmental sanitation, and unsafe disposal of human waste [8-11, 12, 14, 16]. Ethiopia also has one of the world's lowest rates of access to clean drinking water and latrine coverage, which likely contributes to the high prevalence of IPIs in the country [17]. In many parts of Ethiopia, the role of the above-mentioned and other factors in increasing the prevalence of IPIs in HIV patients is unknown [8-11,13,14,16].

Despite numerous earlier studies conducted in various regions of Ethiopia, there remains lack of recent studies done on the prevalence of intestinal parasitic infections (IPIs) and the factors contributing to their transmission among HIV/AIDS patients in the country. In certain areas, such as Oromia, there has been a noticeable increase in HIV/AIDS cases. Moreover, no studies specifically focusing on HIV/AIDS patients have been conducted in the study area, despite high population mobility due to the presence of the Mugher, Dangote, and Medirok cement plants. Therefore, this study aims to assess the current prevalence of IPIs and identify the associated risk factors among HIV patients receiving care at Enchini Hospital in Ethiopia.

Materials and Methods

Study area and population

In 2020, a health-facility-based cross-sectional study was conducted at Enchini Hospital's antiretroviral therapy (ART) clinic. Enchini Hospital is located in Enchini town, which is approximately 65 kilometers from Addis Ababa, the capital city of Ethiopia. The town is located at 90°12'N and 38°017'E, with an altitude of 2693 meters above sea level. According to the Ethiopian Population and Housing Census of 2007, Enchini town has a total population of 124,504, comprising 62,416 males and 62,088 females [20].

Enchini Hospital serves a population of over 130,000 people. Since 2008, the hospital has been offering HIV counseling and testing services. It also acts as a referral center for other health facilities in Enchini town and the surrounding districts, including Meta Robi, Meta Wolkite, and Ejere. Screening, treatment, and follow-up services for HIV/AIDS patients are provided as part of the hospital's routine services.

Data collection

Questionnaire survey

Data on the study participants' socioeconomic characteristics and the risk factors for IPIs were collected using a pre-tested, structured questionnaire. Age, gender, residence, marital status, education status, occupation, and monthly income were among the socioeconomic characteristics collected from participants. Participants were asked questions on a variety of potential risk factors of IPIs, such as drinking water source, hand washing practice, presence of animals in the household, and habit of eating raw vegetables. CD4+ count and ART intake were also extracted from the medical records of the study participants.

Sample size determination and sampling technique

The sample size was estimated using the single population proportion formula [1] with a 17.6% prevalence [9] a margin of error of 5%, and a 95% confidence interval [Z (1− ά/2) = 1.96]. The sources of population were all HIV patients who visited the ART clinic at Enchini Hospital during the study period. The study participants were chosen using a systematic random sampling technique, and the final estimated sample size was 222 HIV/AIDS patients.

Sample collection and laboratory analysis

Stool sample collection

The participants were given clean, labeled feces collection containers and applicator sticks, and they were asked to bring about 5 grams of stool. The date of sampling, as well as the name and gender of the person who brought the samples, were all labeled on each stool collection cup. Two trained laboratory technicians undertook the stool examination independently. The quality of all reagents and supplies used to collect and analyze stool samples was checked before use.

Stool examination

Direct wet mount / iodine mount

After examining the stool samples for their appearance and the presence of certain substances, a wet mount was prepared using 2 grams of stool mixed with normal saline solution. A drop of the emulsified sample was placed on a clean glass slide, and an iodine mount was made on the other side of the slide. Coverslips were then placed at a 45° angle to cover both wet mounts. The samples were examined under a light microscope with 10x and 40x objective lenses to look for motile intestinal parasite larvae, cysts, eggs, and trophozoites [21].

Formal-ether concentration technique

The formal-ether concentration method was employed to analyze the stool samples obtained from participants, as detailed elsewhere [21]. Approximately 1-2 grams of stool samples were placed in a clean 15 ml conical tube with 7 ml of 10% formalin, using a wooden applicator stick. The suspension was then filtered through a sieve (cotton gauze) into a beaker after combining it with the applicator, and the filtrate was transferred back into the same tube. Following the addition of 3 ml of diethyl ether and centrifugation at 2000 rpm for 3 minutes, an iodine stain was prepared using the sediments. Subsequently, the entire area under the coverslip was examined using 10x and 40x objective lenses. Identification of helminth eggs, larvae, cysts, and/or protozoan trophozoites using the wet/iodine mount or formal ether concentration methods resulted in a positive specimen classification.

Modified Ziehl –Neelsen method

Modified Ziehl –Neelsen method was used to detect opportunistic parasites. Thin smear was prepared from the sediment obtained from the formal-ether concentration procedure. Then the smear was air dried and fixed with absolute methanol. After fixing, the smear was stained for 30 minutes with an unheated carbo-fuchsine solution. The stain was decolorized with 1% acid alcohol (99 mL of 96% ethanol and 1mL of HCL) for 1-3 minutes and counterstained with methylene blue for one minute.

under a light microscope with a magnification of 100 [21].

Data analysis

Data were checked for completeness, entered into Microsoft Excel, and then exported to SPSS (SPSS Inc., Chicago, IL, USA) version 25 software for analysis. The frequencies were compared using the chi-squared test. Univariate and multivariate logistic regression analyses were performed to investigate the associations between the dependent and explanatory variables. Variables with p-values lower than 0.25 in the univariate logistic regression were included in the multivariat logistic regression [22]. P-values of 0.05 or lower were considered statistically significant.

Results

The characteristics of the study participants are shown in Table 1. A total of 222 individuals living with HIV/AIDS participated in this study, of whom 43.70% (97) were male. About 40.50% of the participants were between the ages of 31 and 45, 27.50% earned less than or equal to 1500 birr per month, and 38.70% were farmers. While 60.40% of participants lived in rural areas. Moreover, 42.80% of the participants were married, and 38.30% were illiterate (can't read and write) (Table 1).

Table 1: Socio-economic characteristics of the study participants at Enchini hospital (n = 222)

Patient characteristics	Frequency (n)	Percentage
Sex		
Male	97	43.70
Female	125	56.30
Age in groups		
0-15	7	3.70
16-30	80	36.00
31-45	90	40.50
>45	45	20.30
Marital status		
Single	82	36.90
Married	95	42.80
Divorced	32	14.40
Widowed	13	5.90
Residence		
Rural	134	60.40
Urban	88	39.60
Occupation		
Student	45	20.30
Merchant	46	20.70
Employees	31	16.00
Farmer	86	38.70
Unemployed	14	6.30
Level of education		
Primary School	81	36.50
Secondary school	36	15.40
Higher education	22	9.90
Can't read and write	85	38.30
Monthly income		
≤1500 Birr	61	27.50
1501-3000 Birr	56	25.20
3001-4500 Birr	62	27.20
>4500 Birr	43	19.40

Prevalence of intestinal parasites among HIV/AIDS-Positive individuals

Of the 222 stool samples examined, 76 tested positive for one or more intestinal parasites, resulting in an overall intestinal parasitic infection prevalence of 34.2% (76/222) with 95% CI (27.9% - 40.5%). The prevalence of opportunistic parasitic infection was 13.1% (29/222), with *Cryptosporidium parvum* 5.4% (12/222), *Isospora belli* 4.1% (9/222), and *Strongyloides stercoralis* 3.6% (8/222) being the most common. Non-opportunistic parasitic infection was 19.4% (43/222) mostly due to *Entamoeba histolytica / dispar* 12.6% (28/222), *Giardia lamblia* 4.1%

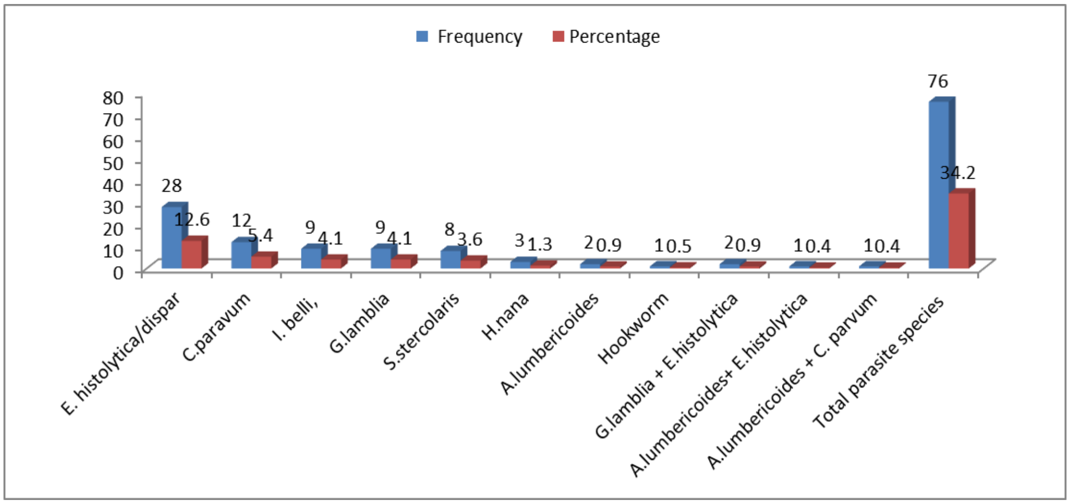

Fig 1: The prevalence of intestinal parasites among HIV/AIDS positive individuals attending Enchini Hospital

Parasitic infections in diarrheic, non-diarrheic, pre-ART and on-ART HIV patients

The prevalence of IPIs among diarrheic and non-diarrheic HIV patients is shown in Table 2. There was a significant difference in the overall parasite infections between diarrheic (52.4 %; 32/63) and non-diarrheic (27%; 43/159) patients. There were significant differences in *C. parvum* ($P < 0.01$) and *I. belli* ($P = 0.009$) infections between diarrheic and non-diarrheic patients. The prevalence of IPIs was significantly higher in patients who were not on ART compared to those who were ($\chi2 = 12.19$, $P = 0.01$). Additionally, there were statistically significant differences in *C. parvum* ($\chi2 = 5.79$, $P = 0.02$), *I. belli* ($\chi2 = 5.81$, $P = 0.02$), and *S. stercoralis* ($\chi2 = 4.78$, $P = 0.02$) infections in patients who did not receive ART compared to those who were on ART (Table 2).

Table 2: The prevalence of intestinal parasitic infections in diarrheic and non-diarrheic HIV patients at Enchini hospital (n = 222)

Parasite species	Diarrheal status				ART status			
	Diarrheic (N = 63) n (%)	Non-diarrheic (N =159) n (%)	Chi-square	P value	Pre-ART (N=110) n (%)	On-ART (N=112) n (%)	Chi-square	P value
E. histolytica / dispar	8(12.7)	20(12.6)	0.01	0.98	18(16.4)	10 (8.9)	2.78	0.09
C.parvum	10(15.9)	2(1.3)	18.85	<0.01*	10(9.1)	2 (1.8)	5.79	0.02*
I.belli	6(9.5)	3(1.9)	8.78	0.009*	8(7.3)	1 (0.9)	5.81	0.02*
G.lamblia	2(3.2)	7(4.4)	0.18	0.68	5(4.5)	4(3.6)	0.14	0.71
S.stercoralis	4(6.3)	4(2.5)	1.91	0.17	7(6.4)	1(0.9)	4.78	0.02*
H.nana	1(1.6)	2(1.3)	0.04	0.85	1(0.9)	2(1.8)	0.32	0.57
A.lumbricoides	0(0)	2(1.3)	0.80	0.37	1(0.9)	1(0.9)	0.00	0.99
Hookworm	0(0)	1(0.6)	0.40	0.53	0(0.0)	1(0.9)	0.99	0.32

G.lamblia & E.histolytica/dispar	**1(1.6)**	**1(0.6)**	**0.46**	**0.49**	**1(0.9)**	**1(0.9)**	**0.00**	**0.99**
A.lumbericoides & E.histolytica/dispr	0(0)	1(0.6)	0.39	0.53	0(0.9)	1 (0.0)	1.02	0.31
A.lumbericoides & C.parvum	1(1.6)	0(0)	2.54	0.11	0(0.0)	1(0.9)	0.99	0.32
Overall prevalence	33 (52.4)	43 (27.0)	12.87	<0.01*	50 (45.5)	26 (23.2)	12.19	<0.01*

n, number of positive cases; N, number of total cases; * Significant difference.

Prevalence of intestinal parasitic infections in relation with CD4$^+$ count

Table 3 shows the prevalence of IPIs by CD4 count. The most common parasites found in patients with CD4 counts of <200 cells/μl and 201-499 cells/μl were *E. histolytica/dispar*, *C. parvum*, and *I. belli*. In patients with a CD4 count of 500 or above, *E. histolytica/ dispar*, *C. parvum*, and *S. stercoralis* were the most common parasites identified. The overall prevalence of IPIs differed significantly between those with a CD4 count of < 200 cells/μl, 201-499 cells/μl, and ≥ 500 cells/μl (χ2= 40.01, P<0.01). There was also a significant difference in *C. parvum* (χ2 = 8.51, P = 0.01), I. belli (χ^2 = 7.13, P = 0.03), and *S. stercolaris* (χ2 = 7.61, P = 0.02) infections between those with a CD4 count of < 200 cells/μl, 201-499 cells/μl, and ≥ 500 cells/μl (Table 3).

Table 3: The prevalence of intestinal parasitic infections in HIV patients by CD4+ counts at Enchini hospital (n = 222)

	CD4 count (cells/μL)				
Parasite species	< 200 (N=23) n (%)	201-499 (N=104) n (%)	≥500 (N=95) n (%)	Chi- square	P-value
E. histolytica / dispar	4 (17.4)	18(17.3)	6 (6.3)	5.97	0.05
C.parvum	4 (17.4)	6 (5.8)	2 (2.1)	8.51	0.01*
I.belli	3 (13.0)	5 (4.8)	1 (1.1)	7.13	0.03*
G.lamblia	1 (4.3)	5 (4.8)	3 (3.2)	0.35	0.84
S.stercoralis	3 (13.0)	4 (3.8)	1 (1.1)	7.61	0.02*
H.nana	1 (4.3)	1 (1.0)	1 (1.1)	1.73	0.42
A.lumbericoides	1 (4.3)	1(1.0)	0 (0)	3.93	0.14
Hookworm	0 (0)	1 (1.0)	0 (0)	1.12	0.57
G.lamblia & E.histolytica / dispar	1 (4.3)	1(1.0)	0 (0)	3.93	0.14
A.lumbericoides&E.histolytica/ dispar	0 (0)	0 (0)	1 (1.1)	1.34	0.51
A.lumbericoides & C parvum	1 (4.3)	0 (0)	0 (0)	8.69	0.01*
Overall prevalence	19(82.6)	42(40.4)	15 (15.8)	40.01	<0.01*

N, total number of cases; n, number of positive cases; * significant difference.

Risk factors associated with intestinal parasitic infection

Table 4 shows factors associated with IPIs. Rural residents were 6.23 (95% CI: 1.70-22.67, P = 0.006) times more likely than urban residents to have intestinal parasites. Patients with a monthly income of less than 1500 birr were 32.06 (95% CI: 4.76- 215.80, P <0.01) times more likely to have IPIs compared to those with a monthly income of more than 4500 birr.

Additionally, patients who used river water as their source of water were 18.04 (95% CI: 5.051- 64.430, P <0.01) times more likely to have IPIs, and those who didn't begin antiretroviral therapy (ART) were 4.14 (95% CI: 1.49- 11.35, P = 0.006) times more likely to have intestinal parasites. The statistical significance for all these associations was found to be below 0.01, indicating a strong correlation. In comparison to individuals with CD4+ counts of 500 cells/µl, those with CD4+ counts of less than 200 cells/µl were 76.02 times more likely to be infected with intestinal parasites (95% CI: 10.196- 566.716, P < 0.01).

Similarly, individuals with CD4+ counts between 201 and 499 cells/µl were 8.5 times more likely to be infected with intestinal parasites (95% CI: 2.66-27.78, P < 0.000). Furthermore, patients who washed their hands before meals and after defecation were 0.08 times less likely to have intestinal parasites than those who did not (95% CI: 0.02-0.31, P < 0.01).

Table 4: Risk factors associated with intestinal parasites among HIV patients at Enchini hospital (n = 222)

Characteristics	Intestinal parasites					
	Positive, n (%)	Negative, n (%)	COR (95% CI)	P value	AOR(95%CI)	P value
Age						
0-15	1(14.3)	6 (85.7)	0.30(0.03-2.74)	0.29	NA	
16-30	26(32.5)	54(67.5)	0.87(0.40-1.88)	0.73	NA	
31-45	33(36.7)	57(63.3)	1.05(0.49-2.21)	0.89	NA	
>45	16(35.6)	29(64.4)	1			
Sex						
Male	37(38.1)	60(61.9)	1.36(0.78-2.38)	0.28	NA	
Female	39(31.2)	86(68.6)	1			
Residence						
Rural	53(39.6)	81(60.4)	1.85(1.03-3.33)	0.04	6.23(1.70-22.67)	0.006
Urban	23(26.1)	65(73.9)	1		1	
Marital status						
Single	24(29.3)	58(70.7)	0.93(0.26-3.32)	0.91	NA	
Married	39(41.1)	56(58.9)	1.57(0.45-5.45)	0.48	NA	
Divorced	9(28.1)	23(71.9)	0.88(0.21-3.59)	0.86	NA	
Widowed	4(30.8)	9(69.2)	1			
Occupation						
Student	12(26.7)	33(73.3)	0.46(0.01-1.89)	0.29	NA	
Merchant	9(19.6)	37(80.4)	0.53(0.13-,2.11)	0.37	NA	
Employees	11(35.5)	20(64.5)	0.60(0.14- 2.59)	0.49	NA	
Farmer	40(46.5)	46(53.5)	3.64(1..06-12.55)	0.04	NA	
Unemployed	4(28.6)	10(71.4)	1			
Education						
Primary	24(29.6)	57(70.4)	1.17(0.59-2.29)	0.65	1.176(0.37-3.78)	0.79
Secondary	13(52.0)	12(48.0)	3.542(1.41-8.91)	0.07	4.83(0.84-27.84)	0.08
Higher education	14(48.3)	15(51.7)	2.98(1.25-7.12)	0.01	3.23(0.61-17.13)	0.17
Uneducated	25(28.7)	62(71.3)	1		1	
Monthly income						
≤1500 etb	18(29.5)	43(70.5)	5.51(2.19-13.82)	0.01	32.06(4.76-215.8)	0.01
1501-3000 etb	21(37.5)	35(62.5)	2.25(0.87-5.79)	0.09	3.17(0.53-19.09)	0.21
3001-45000 etb	17(27.4)	45(72.6)	1.39(0.53-3.66)	0.49	1.12(0.18-6.94)	0.91
>4500 birr	20(46.50	23(53.5)	1		1	
Source of drinking water						
River water	42(59.2)	29(40.8)	5.84(3.05-11.22)	0.01	18.04(5.05-64.43)	0.01
Well water	4(22.2)	14(77.8)	1.165(0.35, 3.83)	0.81	0.35(0.08-2.17)	0.26
Pond water	6(50.0)	6(50.0)	4.04(1.19- 13.64)	0.02	3.69(0.29-46.68)	0.31
Tap water	24(19.8)	97(80.2)	1		1	
Hand washing habit before meal and after defecation						
Yes	14(21.9)	50(78.1)	0.434(0.221, 0.850)	0.02	0.08(0.02-0.31)	0.01
No	62(39.2)	96(60.8)	1		1	
Latrine availability						
Yes	50(30.3)	115(69.7)	0.52(0.28-0.96)	0.03	0.53(0.18-1.57)	0.25
No	26(45.6)	31(54.4)	1		1	

Discussion

This study assessed the prevalence of IPIs and associated risk factors in HIV/AIDS patients at Enchini Hospital in Ethiopia. The overall prevalence of IPIs was 34.2%. Rural residency, a monthly income of less than 500 ETB, CD4 counts of < 200 cells/µl and 2001–499 cells/µl, using rivers as a source of water, not being on ART, and not washing hands before meals and after defecation were all found to be significantly associated with higher IPIs.

The study found that 34.2% of HIV/AIDS patients had IPIs, which is similar to rates reported in other regions of Ethiopia, such as South Central (35.9%) [23], Southern (35.8%) [24] and Eastern (33.7%) Ethiopia [25]. HIV can weaken the immune system, making HIV-infected individuals more susceptible to IPIs [26, 27]. Low public awareness of HIV and intestinal parasites has been linked to a higher risk of IPIs. The higher prevalence of IPIs in this and previous studies may be due to these factors.

This study also found that *C.parvum*, *I.belli*, *E. histolytica/dispar*, and *S. stercolaris* infections were more common in HIV patients who had never had antiretroviral therapy than in those who had. This is consistent with the findings of studies done at Gondar University hospital [28], Dessie Hospital [9], and Hiwot Fana Specialized University Hospital [25] in Ethiopia. ART increases HIV patient survival rates, slows the progression of the disease, decreases viral loads, and fortifies immune systems [29, 30]. Immune system fortification with ART therapy allows HIV patients to fight and eliminate parasitic infections [30]. Thus, this may be the reason for the lower parasitic infections in HIV patients who were on ART than those who never had ART.

The study found that CD4+ counts below 200 cells/µl and 201-499 cells/µl were linked to higher IPIs. This is in agreement with the finding of studies from India [31] and Cameroon [32]. It's been observed that a decrease in CD4+ count due to HIV can lead to heightened susceptibility to opportunistic infections [33]. Additionally, studies in Cameroon and Nepal have shown that opportunistic parasites such as *Cryptosporidium, Cyclospora*, and *I.belli* are common in patients with CD4+ cell counts below 200 cells/µl [34. 35].The elevated IPIs in patients with CD4+ counts below 200 cells/µl and 201-499 cells/µl could be attributed to these factors.

In this study, patients residing in rural areas had a much higher risk of IPIs than those living in urban areas. This finding is consistent with the findings of a study conducted at Dessie Hospital in north-central Ethiopia [36]. Overcrowding, poor personal hygiene, and contamination of water bodies and animals are common in rural than urban communities [37]. This, therefore, could be the reason for the high prevalence of IPIs in this study.

In this study, a monthly income of less than or equal to 1500 birr was also found to be associated with a high risk of intestinal parasitic infections. Other studies in different parts of Ethiopia found a higher prevalence of intestinal parasite infections in people with low income [38-41]. People with a higher income have greater access to sanitation supplies such as toilets, soap, and other facilities, which minimizes their chances of contracting intestinal parasites [42-44].

This study also found that participants whose water source was a river were more likely to be infected by intestinal parasites than those whose water source was tap water. This was consistent with the findings of studies conducted in other parts of Ethiopia, including Dessie [9], Butajira [10], and Gondar [28]. In developing countries like Ethiopia, river water is often contaminated with animal and human waste due to activities like bathing and washing clothes in the river, contributing to the spread of intestinal parasites [45].This could explain the high prevalence of IPIs in this study among participants whose water source was a river.

Participants in this study who washed their hands before meals and after defecation were less likely to have intestinal parasitic infections than those who did not. This is consistent with the findings of a study conducted in Dessie [9] north-central Ethiopia. In Ethiopia, many people are unaware of appropriate hygiene habits such as hand washing before meals and after defecation, which can lead to the spread of intestinal parasites [46]. The Ethiopian government launched the WASH National Program in 2013, with the goal of reducing open defecation and promoting public sanitation, such as hand washing and sanitary facilities [46, 47].

The program produced significant outcomes, including a 17% decrease in open defection and an improvement in hygienic behaviors in schools and households [46-48] However, such a program has gotten little attention in various sections of the country [46-48]. Hand washing before meals and after defecation may have received less attention in the study area, making the study participants less aware of the importance of such habits in reducing IPIs.

Conclusion

This study highlights a significant prevalence (34.2%) of intestinal parasitic infections (IPIs) among HIV-positive individuals in the studied population. Opportunistic infections, particularly *Cryptosporidium parvum* and *Isospora belli*, were notable, especially in patients with lower CD4+ counts and those not on antiretroviral therapy (ART). Socioeconomic factors, such as low income and rural residency, along with poor hygiene practices and untreated water sources, were identified as significant risk factors for IPIs. The strong association between CD4+ count and IPI prevalence underscores the vulnerability of immunocompromised individuals.

The findings emphasize the need for targeted public health interventions, particularly in resource-limited settings. These interventions should focus on improving sanitation, providing access to clean water, promoting hygiene practices, and ensuring timely access to ART. The high prevalence of opportunistic parasites like *Cryptosporidium parvum* and *Isospora belli* in HIV-positive individuals necessitates improved diagnostic and management strategies.

This includes routine screening for these parasites, especially in patients with low CD4+ counts. The study reinforces the importance of ART in reducing the risk of IPIs. Further research is needed to understand the mechanisms by which ART protects against these infections and to optimize treatment regimens.

The strong association between socioeconomic factors and IPIs highlights the need to address the broader social determinants of health in HIV care. Integrated approaches that address poverty, lack of access to clean water, and poor sanitation are crucial. The association between CD4+ count and specific parasitic infections provides valuable insights into the interplay between the immune system and parasitic infections in HIV-positive individuals. Future immunological studies can investigate the specific immune responses associated with these infections.

Limitation of the study

This study has several limitations. First, its cross-sectional design makes it challenging to establish a causal relationship between exposures and outcome variables. Second, since the research was conducted in only one hospital, its findings may not accurately represent the prevalence of IPIs and associated risk factors among HIV/AIDS patients in the general population. Third, the study did not account for all potential risk factors for IPIs in HIV/AIDS patients, indicating the need for further research that considers a broader range of risk factors. Moreover, the study relies on stool sample analysis for parasite detection, with lower sensitivity and specificity as compared to other advanced (molecular) diagnostic methods. This could affect the accuracy of prevalence estimates.

Ethical considerations

The study was approved by the University of Gondar's College of Natural and Computational Sciences' ethical committee, with approval number CNCS/10638-25-5-2020. A written consent form was used to ask for the willingness of the participants to participate in the study. Patients were referred to the hospital's medical unit for treatment if they tested positive for any of the intestinal parasites.

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Conflicts of Interest: The authors declare no conflict of interest

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Authors' Contributions

ST: Identified the research problem, collected and analyzed the data, and participated in the draft and final write-up of the manuscript.
BF: Identified the research problem, collected and analyzed the data, and participated in the draft and final write-up of the manuscript.
DB: Collected and analyzed the data, and participated in the draft and final write-up of the manuscript.
ZT: Collected and analyzed the data, and participated in the draft and final write-up of the manuscript.
AA: Collected and analyzed the data, and participated in the draft and final write-up of the manuscript

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References

1. Brown GV, Goeman J, Piot P. HIV infection and AIDS in the tropics. MJA 1993;159(8):549-51.
2. World Health Organization. Sustaining the drive to overcome the global impact of neglected tropical diseases: second WHO report on neglected diseases. World Health Organization; 2013
3. Joint United Nations Programme on HIV/AIDS., World Health Organization. 2008 report on the global AIDS epidemic. World Health Organization; 2008.
4. Fekadu S, Taye K, Teshome W, Asnake S. Prevalence of parasitic infections in HIV-positive patients in southern Ethiopia: a cross-sectional study. JIDC 2013; 7(11):868-72.
5. Quesada-Lobo L. Key aspects of coccidia associated with diarrhea in HIV patients. AMC 2012; 54(3):139-45.
6. Jemaneh L. The epidemiology of schistosomiasis mansoni and soil-transmitted helminths in elementary school children from the South Gondar Zone of the Amhara National Regional State, Ethiopia. Ethiop Med J 2000; 38(2):105-18.
7. Tefera E, Mohammed J, Mitiku H. Intestinal helminthic infections among elementary students of Babile town, eastern Ethiopia. Pan Afr.Med J 2015;20(1).
8. Alemu A, Shiferaw Y, Getnet G, Yalew A, Addis Z. Opportunistic and other intestinal parasites among HIV/AIDS patients attending Gambi higher clinic in Bahir Dar city, North West Ethiopia. Asian Pac J Trop Med 2011; 4(8):661-5.

9. Missaye A, Dagnew M, Alemu A, Alemu A. Prevalence of intestinal parasites and associated risk factors among HIV/AIDS patients with pre-ART and on-ART attending dessie hospital ART clinic, Northeast Ethiopia. AIDS res and ther 2013; 10(1):1-9.
10. Gedle D, Kumera G, Eshete T, Ketema K, Adugna H, Feyera F. Intestinal parasitic infections and its association with undernutrition and CD4 T cell levels among HIV/AIDS patients on HAART in Butajira, Ethiopia. JHPN 2017 ;36(1):1-0.
11. Teklemariam Z, Abate D, Mitiku H, Dessie Y. Prevalence of intestinal parasitic infection among HIV positive persons who are naive and on antiretroviral treatment in Hiwot Fana Specialized University Hospital, Eastern Ethiopia. Int Sch Res Notices 2013;2013
12. Eshetu T, Sibhatu G, Megiso M, Abere A, Baynes HW, Biadgo B, Zeleke AJ. Intestinal parasitosis and their associated factors among people living with HIV at University of Gondar Hospital, Northwest-Ethiopia. EJHS 2017;27(4):411-20.
13. Alemayehu E, Gedefie A, Adamu A, Mohammed J, Kassanew B, Kebede B, Belete MA. Intestinal parasitic infections among HIV-infected patients on antiretroviral therapy attending debretabor general hospital, Northern Ethiopia: a cross-sectional study. HIV AIDS (Auckl)). 2020 :647-55.
14. Alemu G, Alelign D, Abossie A. Prevalence of opportunistic intestinal parasites and associated factors among HIV patients while receiving ART at Arba Minch Hospital in southern Ethiopia: a cross-sectional study. EJHS 2018; 22;28(2):147-56.
15. Gebretsadik D, Haileslasie H, Feleke DG. Intestinal parasitosis among HIV/AIDS patients who are on antiretroviral therapy in Kombolcha, North Central, Ethiopia: a cross-sectional study. BMC Health Serv Res 2018; 11:1-5.
16. Kloos H, Zein ZA. The ecology of health and disease in Ethiopia. Routledg 2019;11.
17. Kumie A, Ali A. An overview of environmental health status in Ethiopia with particular emphasis to its organization, drinking water and sanitation: a literature survey. EJHD. 2005;19(2):89.
18. Zenu S, Alemayehu E, Woldemichael K. 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. 2019;19:1-0.
19. Hailu GG, Ayele ET. Assessment of the prevalence of intestinal parasitic infections and associated habit and culture-related risk factors among primary schoolchildren in Debre Berhan town, Northeast Ethiopia. BMC public health. 2021 ;21(1):1-2.
20. CSA E. Population and housing census of Ethiopia. Results at country level. 2007.
21. Cheesbrough M. District laboratory practice in tropical countries, part 2. Cambridge university press; 2005.
22. Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. Source code for biology and medicine. 2008 ;3(1):1-8.
23. Getachew T, Hailu T, Alemu M. Prevalence of Opportunistic Intestinal Parasitic Infections Among HIV/AIDS Patients Before and After Commencement of Antiretroviral Treatment at Felege Hiwot Referral Hospital: A Follow-up Study. HIV/AIDS (Auckl) 2021; 16:767-74.
24. Shimelis T, Tassachew Y, Lambiyo T. Cryptosporidium and other intestinal parasitic infections among HIV patients in southern Ethiopia: significance of improved HIV-related care. Parasites & vectors. 2016 ;9:1-7.
25. Teklemariam Z, Abate D, Mitiku H, Dessie Y. Prevalence of intestinal parasitic infection among HIV positive persons who are naive and on antiretroviral treatment in Hiwot Fana Specialized University Hospital, Eastern Ethiopia. Int Sch Res Notices 2013;2013.
26. Heron SE, Elahi S. HIV infection and compromised mucosal immunity: oral manifestations and systemic inflammation. Front Immunol 2017; 7;8:241.
27. Volberding P, editor. Global hiv/aids medicine. Elsevier Hlt Sci 2008.
28. Gebrecherkos T, Kebede H, Gelagay AA. Intestinal parasites among HIV/AIDS patients attending University of Gondar Hospital, northwest Ethiopia. EJHD 2019;33(2).
29. Sztam KA, Fawzi WW, Duggan C. Macronutrient supplementation and food prices in HIV treatment. J Nutr 2010; 1;140(1):213S-23S.
30. Hoenigl M, Chaillon A, Moore DJ, Morris SR, Mehta SR, Gianella S, Amico KR, Little SJ. Rapid HIV viral load suppression in those initiating antiretroviral therapy at first visit after HIV diagnosis. Sci. Rep 2016; 6 (1):32947.
31. Khalil S, Mirdha BR, Sinha S, Panda A, Singh Y, Joseph A, Deb M. Intestinal parasitosis in relation to antiretroviral therapy, CD4+ T-cell count and diarrhea in HIV patients. Korean J Parasitol 2015; 53(6):705.
32. Nsagha DS, Njunda AL, Assob NJ, Ayima CW, Tanue EA, Kibu OD, Kwenti TE. Intestinal parasitic infections in relation to CD4+ T cell counts and diarrhea in HIV/AIDS patients with or without antiretroviral therapy in Cameroon. BMC infect Dis 2015; 16:1-0.
33. Saharia KK, Koup RA. T cell susceptibility to HIV influences outcome of opportunistic infections. Cell. 2013;155(3):505-14.
34. Tiwari BR, Ghimire P, Malla S, Sharma B, Karki S. Intestinal parasitic infection among the HIV-infected pa-

tients in Nepal. JIDC 2013; 7(07):550-5.
35. Ghimire A, Bhandari S, Tandukar S, Amatya J, Bhandari D, Sherchand JB. Enteric parasitic infection among HIV-infected patients visiting Tribhuvan University Teaching Hospital, Nepal. BMC Res Notes 2016; 9:1-5.
36. Feleke DG, Ali A, Bisetegn H, Andualem M. Intestinal parasitic infections and associated factors among people living with HIV attending Dessie Referral Hospital, Dessie town, North-east Ethiopia: a cross-sectional study. AIDS Rese and Ther 2022; 19(1):1-6.
37. Tigabu A, Taye S, Aynalem M, Adane K. Prevalence and associated factors of intestinal parasitic infections among patients attending Shahura Health Center, Northwest Ethiopia. BMC Res notes. 2019 ;12:1-8.
38. Gelaw A, Anagaw B, Nigussie B, Silesh B, Yirga A, Alem M, Endris M, Gelaw B. 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 2013;13:1-7.
39. Buchala AD, Mengistu ST, Mue AD, Gujo AB. Prevalence of intestinal parasitic infections and associated factors among pregnant women attending antenatal care at Yirgalem General Hospital, Sidama, Ethiopia. CEGH 2022; 1;15:101032.
40. Abera W, Gintamo B, Shitemaw T, Mekuria ZN, Gizaw Z. Prevalence of intestinal parasites and associated factors among food handlers in food establishments in the Lideta subcity of Addis Ababa, Ethiopia: an institution-based, cross-sectional study. BMJ open. 2022 ;12(7):e061688.
41. Marami D, Hailu K, Tolera M. 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. 2018 Dec;30:1-7.
42. De Silva NR, Brooker S, Hotez PJ, Montresor A, Engels D, Savioli L. Soil-transmitted helminth infections: updating the global picture. Trends in parasitol 2003 ;19(12):547-51.
43. Woldu W, Bitew BD, Gizaw Z. Socioeconomic factors associated with diarrheal diseases among under-five children of the nomadic population in northeast Ethiopia. Trop med hlt 2016 ;44(1):1-8.
44. Rahman A. Assessing income-wise household environmental conditions and disease profile in urban areas: study of an Indian city. GeoJournal 2006; 65:211-27.
45. Eriksson M, Sigvant J. Causes and impact of surface water pollution in Addis Ababa, Ethiopia.
46. United Nations Children's Fund (UNICEF). (2018). WASH in Schools in Ethiopia: Policy and Implementation Brief. Accessed May 2, 2023 from https://www.unicef.org/ethiopia/media/478/file/WASH-in-Schools-in-Ethiopia-Policy-and-Implementation-Brief-2018.pdf.
47. USAID. (2018). Ethiopia Water, Sanitation, and Hygiene (WASH) Program. Accessed May 2, 2023 from https://www.usaid.gov/ethiopia/water-sanitation-and-hygiene-wash-program.
48. Ministry of Water, Irrigation and Energy (2019). National Hygiene and Sanitation Strategy (2019-2030).AccessedMay2,2023from https://washdata.org/sites/default/files/documents/reports/2019 06/ Ethiopia_WASH_Sector_Statistical_Report_2018.pdf.