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Prevalence of opportunistic intestinal coccidian parasites and associated factors in HIV/AIDS patients attending anti-retroviral therapy (ART) clinic at Debre Tabor Comprehensive Specialized Hospital, Northwest Ethiopia: A cross-sectional study

Andargachew Almaw | **Ayenew Assefa** | **Ayenew Berhan** | **Ermiyas Getahun** | **Bekele Sharew** | **Tegenaw Tiruneh** | **Birhanu Getie** | **Mulat Erkihun** | **Yenealem Solomon** | **Biruk Legese** | **Teklehaimanot Kiros** | **Aynework Abebaw**

Department of Medical Laboratory Science, College of Health Sciences, Debre Tabor University, Debre Tabor, Ethiopia

Correspondence
Andargachew Almaw, Department of Medical Laboratory Science, College of Health Sciences, Debre Tabor University, Debre Tabor, Ethiopia.
Email: andargachewalmaw@gmail.com

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Abstract

Background and Aims: A growing number of acquired immunodeficiency syndrome (AIDS) patients suffer from opportunistic intestinal coccidian infections. Instead of human immuno deficiency virus (HIV) infection itself, opportunistic infections like intestinal coccidian parasites cause death of over 80% AIDS patients. Factors like exposed drinking water sources and poverty aid the prevalence of opportunistic intestinal coccidian parasitic infections in HIV/AIDS patients. The goal of this study was to determine the prevalence of intestinal coccidian parasites and associated factors in HIV/AIDS patients.

Methods: A health facility based cross sectional study was conducted from 140 HIV/AIDS patients attending ART clinic in Debre Tabor Comprehensive Specialized Hospital, Northwest Ethiopia from September to December 2023. The socio-demographic characteristics were collected through face-to-face interviews. Stool samples were processed with Modified Acid Fast staining technique. Statistical Package for Social Sciences software version 20 was used to analyze the data. Logistic regression was used to assess factors associated with dependent variable and $p < 0.05$ was considered significantly associated.

Results: The total prevalence of opportunistic intestinal coccidian parasites (OICPs) in HIV/AIDS patients was 16.4% (23/140). Drinking surface water [$p = 0.015$, COR = 3.4] compared to tape water, drinking alcohol [$p = 0.001$, COR = 18] compared to not drinking alcohol, diarrhea [$p = 0.005$, COR = 1] compared to non-diarrheic, drug dropout [$p = 0.01$, COR = 11] compared to regular drug intake and low CD4 count [$p = 0.042$, COR = 9] compared to CD4 > 500/µL showed significant association with increased prevalence of OICPs in HIV/AIDS patients.

Conclusions: OICPs are still the common causes of morbidity and mortality in HIV/AIDS patients. Surface water consumption, alcoholism, interruption of treatment drugs, diarrhea, and reduced $CD4^+$ T-cells significantly contribute to acquisition and prevalence of OICPs in HIV/AIDS patients. Routine screening of OICPs with sensitive diagnostic techniques in HIV/AIDS patients regardless of symptoms is crucial and has to be practiced in health settings.

KEYWORDS

Ethiopia, factors, HIV/AIDS, intestinal coccidian, opportunistic, prevalence

1 | BACKGROUND

Human immuno deficiency virus (HIV) is the virus that primarily attacks the immune system, the body's normal protection against many infections.[1] HIV infection to be one of the commonest causes of mortality in humans aged 25–44 years, ranking 13th among the killers in 2021.[2] HIV can cause acquired immunodeficiency syndrome (AIDS). A higher risk of potentially fatal infections and malignancies arises from the immune system's slow and continuous deterioration and failure caused by AIDS.[3]

By considering genetic and antigenic variations, HIV is classified into two divisions as HIV-1 and HIV-2 with HIV-1 being the most infectious and highly distributed.[4,5] The main targets of HIV are Cluster of Differentiation 4-positive ($CD4^+$) cells, primarily $CD4^+$ T helper lymphocytes.[6] For effective invasion of HIV, CD4 receptor and the C-C chemokine receptor type 5 (CCR5) or C-X-C chemokine receptor type 4 (CXCR4) co-receptor are needed to be present on the host cell.[7,8] Infection leads to the death of the host cell resulting in exhaustion of $CD4^+$ T lymphocytes.[9] As the adaptive immune system's regulators, $CD4^+$ T lymphocyte depletion essentially impairs the immune system, resulting in the infection's AIDS stage.[6]

According to the World Health Organization 2023 report, approximately 39.0 million people were living with HIV at the end of 2022 and 630,000 individuals had died from HIV-related causes worldwide.[10] Approximately, 29.8 million individuals infected with HIV were receiving antiretroviral therapy in the world. Of the global burden, about 25.6 million people living with HIV in 2022 have been reported from the African region with predicted 380,000 deaths. In the African region, an estimated 20.9 million people were receiving antiretroviral therapy in 2022.[10]

HIV infected patients developing progressive phases of the virus are more vulnerable to secondary microbial and parasitic infections known as opportunistic infections. This is because opportunistic infections exploit the opportunity presented by a compromised immune system. Approximately 80% of HIV/AIDS patient deaths are attributable to opportunistic infections than the virus itself, and of these, over 47% are caused by opportunistic intestinal parasitic infections, which often impact the gastrointestinal tract before spreading to other body areas.[11]

HIV/AIDS-related gastrointestinal problems brought on by opportunistic parasite infections manifest as diarrhea and serious illness; these complications have been documented in 50%–96% of cases globally, with 90% of cases occurring in Africa.[12] The development of AIDS to its peak manifests itself by infection with opportunistic parasites.[12] A growing number of AIDS patients are suffering with opportunistic intestinal protozoan infections. When $CD4^+$ T-cell count falls below 200/µL, opportunistic infections typically happen late in the course of HIV infection.[13]

Immunocompromised people are most frequently infected by opportunistic intestinal protozoa (OIPs), also known as intestinal coccidian parasites. *Isospora belli*, *Cyclospora cayetanensis*, and *Cryptosporidium* species are the intestinal coccidian protozoan parasites that cause opportunistic infections in AIDS patients most frequently.[12–14] Opportunistic intestinal coccidian parasites (OICPs) may induce self-limiting diarrhea in immunocompetent persons, but in HIV/AIDS patients, the diarrhea remains more severe. In patients with $CD4^+$ T cell counts <200/µL chronic, persistent, and unusually copious diarrhea resulting in severe fluid and electrolyte loss occur with weight loss and abdominal pain.[15]

In nations with widespread access to antiretroviral medications, the prevalence of intestinal parasites among HIV-positive people has significantly dropped.[16] Nonetheless, intestinal parasitic infections are still the commonest cause of diarrhea and weight loss in the majority of resource-constrained nations where patients lack access to ART.[17,18] Patients with AIDS frequently experience severe, ongoing infections that recur quickly when adequate treatment is stopped. Among the opportunistic parasites, *I. belli*, *C. parvum*, *C. cayetanenis* and *microsporidia* species are progressively reported as causes of enteritis and as opportunistic pathogens in immune suppressed hosts.[13,19]

Although, majority of health facilities have access to HIV/AIDS care and ART centers in Ethiopia, the routine screening of opportunistic intestinal parasites is not being conducted. The only candidates for intestinal parasite screening are patients with diarrhea and other abdominal complications. Such patients are even diagnosed routinely with direct saline wet mount which has low detection rate of intestinal coccidian parasites. Therefore, such patients with intestinal coccidian parasites remain misdiagnosed which results in mistreatment, delayed treatment, severe complications, and even death. In addition, the actual prevalence remains under reported.[20] Indeed, it is vital to detect intestinal coccidian parasites with sensitive and appropriated diagnostic techniques like modified Acid Fast Staining of the parasites.[20]

A number of factors like poor sanitation, exposed drinking water sources, absence of latrine utilization, improper sanitation and hygiene practices, low socioeconomic status and overpopulation are considered to have significant contribution in the prevalence of intestinal coccidian parasitic infections in HIV/AIDS patients in developing countries like Ethiopia.[20–22] However, data about the prevalence of intestinal coccidian parasites and contributing factors is not documented in the study area. Therefore, this study aimed to determine the prevalence of intestinal coccidian parasites and associated factors in HIV/AIDS patients attending ART center at Debre Tabor Comprehensive Specialized Hospital (DTCSH), Northwest Ethiopia.

2 | METHODS AND MATERIALS

2.1 | Study design, period, and area

A health facility based cross sectional study was conducted from September to December 2023, at Debre Tabor Comprehensive Specialized Hospital, Northwest Ethiopia. The hospital is located in Debre Tabor town, the capital of South Gonder Zone in Amhara region, Northwest Ethiopia. The hospital provides preventive, delivery and curative health care services for about ~2.7 million people in the zone and nearby districts. It provides inpatient and outpatient diagnostic services including ART clinic service for HIV/AIDS patients.

2.2 | Dependent and independent variables

The dependent variable was intestinal coccidian parasites infection status. The independent variables were age, sex, residence, educational status, occupation, source of drinking water, habit of washing hands before eating and after toilet, latrine utilization, alcohol drinking habit, drug dropout, diarrhea, and CD4 count.

2.3 | Eligibility criteria

2.3.1 | Inclusion criteria

HIV/AIDS patients who visit ART clinic for follow up during the study period and voluntary to participate were included.

2.3.2 | Exclusion criteria

HIV/AIDS patients who were severely ill and unable to respond as well as those who have taken anti parasitic drugs were excluded.

2.4 | Sample size determination and sampling technique

A single population proportion formula with an 8.9% prevalence in a prior study,[20] a 95% confidence level, a 5% margin of error, and a 10% nonresponse rate were used to calculate the sample size. The result was a total sample size of about 140. Therefore, 140 HIV/AIDS patients attending ART clinic were included and enrolled by convenience sampling technique.

2.5 | Data collection

2.5.1 | Sociodemographic data collection

Using a standardized questionnaire as a data collection method, in-person interviews were used to gather the sociodemographic data. The questionnaire was prepared in English version. The English version of the questionnaire was translated to the local language (Amharic). About 5% (7) of the questionnaires were pre-tested to ensure the quality of the data before starting collection.

2.5.2 | Stool sample collection and processing

sing a dry, clean, and labeled feces container, study participants' stool samples were gathered. A 15 mL conical centrifuge tube was filled with 1 g of feces sample, 10 mL saline, and a double layer of moist gauze for sieving. Subsequently, 3 mL of ether and 10 mL of 10% formalin were added to the tube. For 5 min, the tube was centrifuged at 2000 rpm The concentrated stool sediment was used to make a thin smear, which was then allowed to air dry before being processed with modified Ziehl Nelson staining of oocysts.[23] The air dried smear was stained with unheated Carbol fuchsin for 15 min and washed with water. After washing, 1% acid alcohol was added for 15 s to decolorize and washed with water. Then, a counter stain (0.5% methylene blue) was added for 30 s. The stain was washed off and allowed to air dray. After drying, the smear was examined under light microscope at low power magnification and oil immersion objective for detection and identification of Oocysts.[23] The $CD4^+$ T cell count of the study participants was obtained from their medical record or chart. The overall workflow of data collection is described in the following figure (Figure 1).

2.6 | Data quality control

The data collectors received instruction on how to gather, record, and save data before beginning the data gathering process. Before beginning data collecting, about 5% (7) of the questions underwent pre-testing to guarantee the accuracy, comprehensiveness, and clarity of the information. Every day, the completeness of the data was verified. Every day, internal quality control was examined

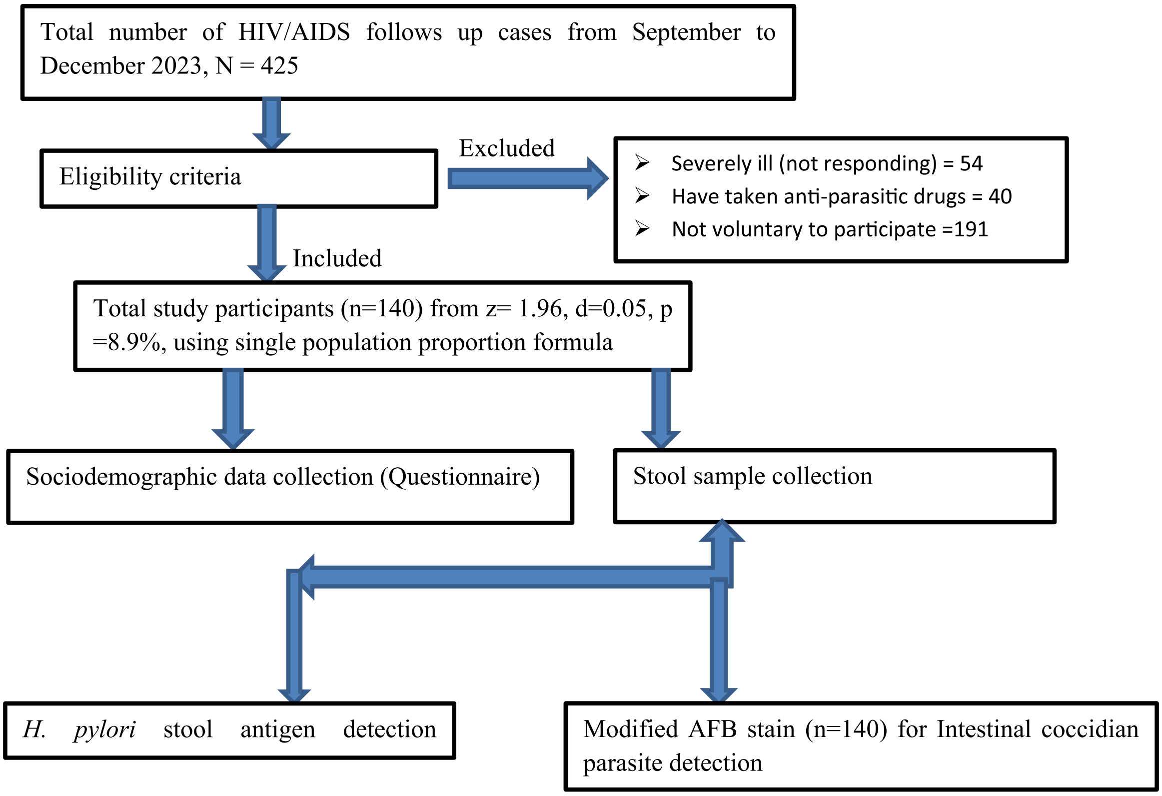

FIGURE 1 Flow chart indicating workflow of the data collection on HIV/AIDS patients at Debre Tabor Comprehensive Specialized hospital, Northwest Ethiopia (September to December 2023).

using preserved positive intestinal coccidian parasite samples to make sure the reagents were working properly and to minimize errors in result interpretation. Standard operating procedures were properly followed during the processing of the samples and laboratory analyzes.

2.7 | Data analysis

The collected data were given the codes, entered, cleaned and analyzed using Statistical Package for Social Sciences software version 20 (SPSS 20). Descriptive statistics (frequencies, mean and percentage) were used to explain the study participants in relation to the variables. Logistic regression was used to assess the association between the dependent and independent variables. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated and variables with $p < 0.05$ were considered statistically significant.

2.8 | Ethical consideration

This study was reviewed by the Department of Medical Laboratory Science, Debre Tabor University research review committee with the approval number (97/2023/). Written informed consent and assent was obtained from the study participants and guardians, respectively.

3 | RESULTS

3.1 | Sociodemographic characteristics of study participants

A total of 140 HIV/AIDS patients participated in the study, of which 58.6% (82/140) were males. The majority of the study participants, 85% (119/140) were adults with age range of 15–50 years old. Similarly, the majority of the study participants were urban residents (Table 1).

3.2 | Prevalence of OICPs in HIV/AIDS patients at DTCSH ART clinic

The overall prevalence of OICPs in HIV/AIDS patients attending DTCSH ART clinic was 16.4% (23/140). The most prevalent OICP was the *Cryptosporidium* species (Table 2).

3.3 | Distribution of OICPs in HIV/AIDS patients with diarrhea and $CD4^+$ T lymphocytes

Out of the total patients who developed OICPs observed, Diarrhea was registered in 42.9% (60/140) of HIV/AIDS patients. From the total HIV/AIDS patients with OICPs, 82.6% (19/23) had diarrhea.

TABLE 1 Socio-demographic characteristics of study participants at DCSH ART clinic, Northwest Ethiopia, 2023.

Variables	Category	Frequency	Percent (%)
Sex	Male	58	41.4
	Female	82	58.6
Age	<15	2	1.4
	15–50	119	85
	>50	19	13.6
Residence	Urban	88	62.9
	Rural	52	37.1
Educational status	Can't read and write	28	18.6
	Primary school	56	40
	Secondary and above	58	41.4
Occupation	Government employed	110	78.6
	Private	30	21.4
Alcohol drinking habit	Yes	60	42.9
	No	80	57.1
Drinking water source	Surface water	71	50.7
	Piped water	69	49.3
Drug dropout	Yes	54	38.6
	No	86	61.4

TABLE 2 Prevalence of opportunistic intestinal coccidian parasites in HIV/AIDS patients attending DTCSH ART clinic, Northwest Ethiopia, 2023.

Result	Proportion %
Total positive	16.4% (23/140); (95% CI: 10.7%–22.9%)
Cryptosporidium spp.	11.4% (16/140); (95% CI: 7.2%–17.8%)
Cyclospora spp.	2.1% (3/140); (95% CI: 0.7%–6.1%)
Isospora belli	2.9% (4/140); (95% CI: 1.1%–7.1%)

Abbreviation: CI, confidence interval.

Similarly, the highest number of patients with OICPs 69.6% (16/23), were those having CD4 counts less than 200 cells/μL (Table 3).

3.4 | Factors associated with the prevalence of OICPs in HIV/AIDS patients

Factors associated with the prevalence of OICPs in HIV/AIDS patients were assessed using logistic regression analyzes. In bivariate logistic regression analysis, the study variables with $p \leq 0.2$ were selected and imported to the multivariate logistic regression analysis.

TABLE 3 Distribution of opportunistic intestinal coccidian parasites in HIV/AIDS patients at DTCSH ART clinic, Northwest Ethiopia, 2023.

Intestinal coccidian parasites detected	Diarrhea and CD4 status						
	Diarrhea			CD4$^+$ T lymphocytes/μL			
	Yes	No	Total	<200	200–500	>500	Total
Cryptosporidium spp.	14	2	16	12	2	2	14
Cyclospora spp.	2	1	3	2	1	0	3
I. belli	3	1	4	2	1	1	4
Total positive	19	4	23	16	4	3	23
Total negative	41	76	117	32	43	42	117
Total examined	60	80	140	48	47	45	140

Finally, surface water consumption [($p = 0.015$, COR (95% CI): 3.4 (6.4, 17.80))], drinking alcohol [($p = 0.001$, COR (95% CI): 18 (3.30, 10.72))], diarrhea [($p = 0.005$, COR (95% CI): 18 (2.40, 14.20))], drug dropout [($p = 0.010$, COR (95% CI): 11 (1.80, 6.31))] and low CD4$^+$ T cell count (<200/μL) [($p = 0.042$, COR (95% CI): 9 (2.10, 7.54))] were the factors identified to have statistically significant association with the prevalence of OICPs in HIV/AIDS patients (Table 4).

4 | DISCUSSION

Opportunistic infections of the parasites are one of the commonest causes of disease and death in HIV/AIDS patients and result in loss of a number of lives every year. The development of OICPs in HIV/AIDS patients, primarily *Cryptosporidium* species, *Cyclospora* species and *Isospora belli* have been documented in different studies.[12–15,20–22]

In the present study, the overall prevalence of OICPs in HIV/AIDS patients is 16.4% (23/140); (10.7%–22.9%) which is in line with the study results reported in Arba Minch hospital, Southern Ethiopia (15.5%),[21] Jima, Ethiopia (15.38%)[14] and eastern Ethiopia (14.5%).[24] However, the prevalence of OICPs in HIV/AIDS patients in the present study is lower than the study findings conducted in India (33%),[25] Gambi Higher clinic/Bahirdar, Ethiopia/(52.8%)[17] and Nigeria (76.7%).[26] On the other hand, the result in the present study is higher than the reports from studies conducted in Cameron (9.7%),[27] Hiwot Fana Specialized University Hospital, Eastern Ethiopia (3.5%),[28] Bahir Dar, Ethiopia (8.9%),[20] and Dessie hospital, Northern Ethiopia (1.1%).[29] The existing variations in prevalence findings might be attributed to the different characteristics between studies like sample size, diagnostic techniques applied, the treatment applications and the immune status variations between patients in different areas. In addition, different sociodemographic settings and societal circumstances, related for example with nutrition and hygiene can be attributed to the existing variations.

TABLE 4 Factors associated with the prevalence of opportunistic intestinal coccidian parasites in HIV/AIDS patients at DTCSH ART clinic, Northwest Ethiopia, 2023.

Variables	Category	OICPs Positive	OICPs Negative	COR	*p* value	AOR	*p* value
Residence	Rural	12	40	2.1 (1.85, 5.18)	0.107	2.3 (5.1, 10.50)	0.281
	Urban	11	77	1			
Educational status	Illiterate	11	15	7.7 (2.34, 5.90)	0.001	2.6 (0.59, 5.60)	0.354
	Primary	7	49	1.5 (0.45, 5.09)	0.152	1.6 (3.01, 9.21)	0.611
	≥Secondary	5	53	1			
Occupation	Private	19	68	3.4 (3.10, 10.70)	0.034	8 (1.10, 6.50)	0.054
	Employed	4	49	1			
Source of drinking water	Surface water	19	52	5.9 (2.00, 8.53)	0.002	3.4 (6.4, 17.80)	0.015
	Pipe water	4	65	1			
Alcohol drinking habit	Yes	18	27	12 (4.10, 7.34)	<0.001	18 (3.30, 10.72)	0.001
	No	5	90	1			
Diarrhea	Yes	19	41	8.8 (2.81, 7.62	<0.001	18 (4.20, 14.20)	0.005
	No	4	76				
Drug dropout	Yes	18	36	8.1 (2.80, 5.52)	<0.001	11 (2.80, 6.31)	0.010
	No	5	81	1			
CD4 count	<200/µL	16	32	7 (1.90, 6.10)	0.04	9 (2.10, 7.54)	0.042
	200–500/µL	4	43	1.3 (2.80, 6.20)	0.001	2.1 (2.40, 7.83)	0.005
	>500/µL	3	42	1			

Abbreviations: AOR, adjusted odds ratio; OICP, opportunistic intestinal coccidian parasites.

Cryptosporidium species is the most prevalent [11.4% (16/140); (7.2%–17.8%)] intestinal coccidian detected in the current study. This result was consistent with the prevalence of *Cryptosporidium* species reported in Arba Minch hospital, Southern Ethiopia (8.63%),[21] Eastern Ethiopia (16.7%)[24] and Jima, Ethiopia (8.9%).[14] However, a study by Sinha et al.[25] in India (27%), Nigeria (41.6%),[26] and Gambi Higher clinic/Bahirdar, Ethiopia/(33.1%),[17] have reported relatively higher prevalence of *Cryptosporidium* than the present study. Unlikely, the prevalence of *Cryptosporidium* in the present study is higher than the findings reported in Hiwot Fana Specialized University Hospital, Eastern Ethiopia (2.1%),[28] Democratic Republic of Congo (9.7%)[30] and Cameron (3.9%).[27] The difference between the findings might be related to the variation in sample size, duration of study period, diagnostic techniques as well as different environmental and personal factors in different areas.

Isospora belli is the second most prevalent [2.9% (4/140) (1.1%–7.1%)] OICP in HIV/AIDS patients in the current study. This result is in line with the findings reported by Sinha et al.[25] in India (4.7%), Cameron (1.9%),[27] Hiwot Fana Specialized University Hospital, Eastern Ethiopia (1.3%),[28] Arba Minch hospital, Southern Ethiopia (1.4%)[21] Jima, Ethiopia (6.6%)[14] and Democratic Republic of Congo (1.7%).[30] On the contrary, relatively higher prevalence of *Isospora belli* has been reported in Gambi Higher clinic/Bahirdar, Ethiopia/(11.7%),[17] Eastern Ethiopia (10.4%)[24] and Nigeria (31.1%).[26] This difference in prevalence can be attributed to the aforementioned reasons. The least prevalent [2.1% (0.7%–6.1%)] OICP in HIV/AIDS patients in the present study is *Cyclospora* species. This result is in line with the results reported by Alemu et al.[21] in Arba Minch hospital, Southern Ethiopia (5.9%), and India (1.3%)[25]

In the present study, a number of factors contributing to the development and prevalence of opportunistic intestinal coccidian parasitic infections in HIV/AIDS patients have been identified. Among the significant factors are: Source of drinking water, alcohol drinking habit, diarrhea, drug dropout and $CD4^{+}$ T cells. Surface water consumption (AOR = 3.4, 95% CI: 6.4–17.80, $p = 0.015$) showed significant association with the development of opportunistic intestinal coccidian parasitic infections in HIV/AIDS patients compared to tap water. This is directly related to the feco-oral transmission of these parasites. Because, surface water is less protected than tap water and can be easily contaminated. According to the findings in our study, HIV/AIDS patients drinking surface water are 3.4 times more likely to acquire and develop opportunistic intestinal coccidian parasitic infections than drinking tap water. This finding is supported by the findings in previously conducted studies.[20,24,29]

Drinking alcohol (AOR = 18, 95% CI: 3.30–10.72, $p = 0.001$) is also found to be significantly associated with increased development and prevalence of opportunistic intestinal coccidian parasitic infections in HIV/AIDS patients. According to the present study, HIV/AIDS patients who have habit of drinking alcohol are 18 times more likely to develop opportunistic intestinal coccidian parasitic infections compared to HIV patients who do not drink alcohol. Many people living with HIV still consume alcohol for a number of reasons, such as self-medication and leisure. Because alcohol relaxes the body and brain, it can promote relaxation, reduce stress, and stimulate hunger.[31] People who are HIV positive may experience severe mental pain, and alcohol seems to offer some fleeting solace. However, alcohol consumption has negative impacts on immunity and weakens the immune system and HIV/AIDS patients with weakened immunity get opportunistic infections more easily and will not be able to clear out these parasites after susceptibility.[31]

Interruption of HIV/AIDS drugs (AOR = 11, 95% CI: 2.80–6.31, $p = 0.010$) is also a very significant contributing factor for infection with OICPs. In this study, HIV/AIDS patients who interrupt drugs are 11 times more likely to acquire opportunistic intestinal coccidian parasitic infections. Because, HIV advances in stages if drug is interrupted leading to crushing the immune system and getting worse over time. Due to the significant immune system damage caused by AIDS, individuals with AIDS are more susceptible to serious infections known as "opportunistic infections."[31] This finding is supported by Teklemariam et al.[29] and, Adamu and Petros[24] who found that opportunistic parasites were significantly higher in HIV/AIDS patients without treatment. Antiretroviral treatment increases the immunity status of HIV positive persons and decreases the incidence of opportunistic infections.[32]

Diarrhea is another significant factor indicating the development of OICPs in HIV/AIDS patients. In our study, HIV/AIDS patients with diarrhea are 18 times more likely to have OICPs than patients without diarrhea. This finding is supported by previous studies.[25,33,34] In study by Sinha et al.[25] in India, prevalence of opportunistic parasites was significantly higher in subjects with diarrhea than without diarrhea.

The number of $CD4^+$ T-cells is among the significant contributing factors for prevalence of OICPs (AOR = 9, 95% CI: 2.10–7.54, $p = 0.042$) in HIV/AIDS patients. In our study, HIV/AIDS patients with low $CD4^+$ T-cells count (<200/μL) are 9 times more likely to have OICPs compared to HIV/AIDS patients with $CD4^+$ T-cells count >500/μL. This finding was supported by similar findings in earlier studies.[24–26,28,35,36] For example, according to the study conducted in Nigeria,[26] low $CD4^+$ T-cells count (<200/μL) was highly significantly associated with the presence of coccidian parasites. This is because HIV/AIDS patients with reduced CD4 are in immune deficient state which makes them more susceptible to opportunistic infections and once established, they will not be able to clear out these infections.[37] Similarly, HIV/AIDS patients with $CD4^+$ T-cells between 200 and 500/μL were 2.1 times more likely to have OICPs.

5 | CONCLUSIONS

OICPs are still the major causes of severe morbidity and mortality in HIV/AIDS patients. Drinking from surface water source, alcoholism, interruption of treatment drugs, diarrhea and reduced $CD4^+$ T-cells are the most significant contributing factors to acquisition and prevalence of OICPs in HIV/AIDS patients. Reducing exposure to these factors is crucial to reduce morbidity and mortality in patients with HIV/AIDS. Moreover, routine screening of OICPs with sensitive diagnostic techniques in HIV/AIDS patients regardless of symptoms is very important intervention strategy and has to be practiced in every health settings.

AUTHOR CONTRIBUTIONS

Andargachew Almaw: Conceptualization; Investigation; Writing—original draft; Methodology; Visualization; Writing—review and editing; Software; Formal analysis; Data curation. **Ayenew Assefa**: Investigation; Validation. **Ayenew Berhan**: Conceptualization; Writing—review and editing. **Ermiyas Getahun**: Conceptualization; Investigation; Writing—original draft; Visualization. **Bekele Sharew**: Conceptualization; Validation; Data curation. **Tegenaw Tiruneh**: Investigation; Visualization; Software. **Birhanu Getie**: Writing—review and editing; Formal analysis. **Mulat Erkihun**: Investigation; Supervision. **Yenealem Solomon**: Conceptualization; Visualization; Supervision. **Biruk Legese**: Investigation; Visualization. **Teklehaimanot Kiros**: Conceptualization; Writing—review and editing; Supervision. **Aynework Abebaw**: Conceptualization; Investigation; Writing—review and editing; Formal analysis.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article. The data supporting the findings of the study are available within the article.

TRANSPARENCY STATEMENT

The lead author Andargachew Almaw affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ORCID

Andargachew Almaw http://orcid.org/0000-0002-4895-3017
Ayenew Assefa http://orcid.org/0000-0003-4287-4147

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