HIV/AIDS – Research and Palliative Care

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ORIGINAL RESEARCH

Magnitude of opportunistic infections and associated factors in HIV-infected adults on antiretroviral therapy in eastern Ethiopia

This article was published in the following Dove Press journal:
HIV/AIDS – Research and Palliative Care
12 May 2015
Number of times this article has been viewed

Habtamu Mitiku
Fitsum Weldegebreal
Zelalem Teklemariam

Haramaya University, College of Health and Medical Sciences, Department of Medical Laboratory Sciences, Harar, Ethiopia

Purpose: The aim of this study was to assess the prevalence of opportunistic infections (OIs) and associated factors among HIV-infected adults on anti-retroviral therapy (ART) in Hiwot Fana Specialized University Hospital, Eastern Ethiopia.

Patients and methods: A hospital-based retrospective study was conducted in 358 HIV-infected adult patients on ART from April to June 2014. Data were collected through review of clinical records. The data was entered and analyzed by using SPSS version 16.0. Univariate and multivariate analyses were performed to determine the association of each independent variable with occurrence of OIs. A 95% confidence interval (CI) and *P*-value less than 0.05 were considered as significant association.

Results: A total of 358 patients were included in the study, in which majority (68.4%) were females. The mean age of patients was 34 (standard deviation [SD] ±9.8) years. The overall of prevalence of OIs among HIV/AIDS patients on ART was 48%. The highest prevalent rates of OIs observed were tuberculosis (TB) (21.23%), followed by Herpes zoster (11.2%) and oral candidiasis (9.5%). Baseline CD4 cell count <200 cells/mm^3 (adjusted odds ratio [AOR] =1.645, 95% CI =2.187, 3.983), baseline World Health Organization (WHO) clinical stage III (AOR =2.801, 95% CI =1.958, 7.165) and IV (AOR =3.856; 95% CI =2.691, 10.390), and not using prophylaxis (AOR =1.912, 95% CI =1.444, 3.824) were found to have strong association with acquisition of OIs.

Conclusion: There was a high prevalence of OIs observed in this study. Baselines CD4 count of <200 cells/mm^3, advanced WHO clinical stages, and not using prophylaxis were found to be predictors of OIs. Interventions were aimed at promoting early HIV testing and enrollment of HIV-infected individuals into ART services needed before CD4 count decreased severely.

Keywords: AIDS, CD4, prophylaxis, WHO clinical stage

Introduction

HIV causes progressive depletion of the CD4 T cells, which leads to life-threatening opportunistic infections (OIs) or malignancies during the natural course of the disease.[1–5] More than 90% of OIs are responsible for the development of AIDS morbidities and mortalities.[1]

The most common opportunistic diseases in HIV patients in Ethiopia are oropharyngeal candidiasis and tuberculosis (TB), followed by diseases of the central nervous system (CNS), sepsis, *Pneumocystis carini* pneumonia (PCP), bacterial pneumonia, Kaposi's sarcoma, and lymphoma.[1] In general, milder infections such as Herpes zoster and other skin infections occur in early World Health Organization (WHO) clinical stages (stages I and II),[6] whereas serious, life-threatening infections such as

Correspondence: Habtamu Mitiku
Haramaya University, College of Health and Medical Sciences, Department of Medical Laboratory Sciences, PO Box 235, Harar, Ethiopia
Email habtemit@gmail.com

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CNS toxoplasmosis and cryptococcal meningitis occur in later WHO clinical stages (stages III and IV) with severe immunity suppression. Some life-threatening infections, such as pneumonia and TB, may occur in early as well as in later WHO clinical stages.[1,2] The risk for the development of OIs in HIV patients depends on exposure to potential pathogens, virulence of the pathogens, the degree of host immunity, and the use of antimicrobial prophylaxis.[3]

Antiretroviral therapy (ART) increases the length and quality of life and productivity of patients by improving survival, and decreases the incidence of OIs in HIV-infected people through reduction of the viral load and increasing the level of CD4 cells.[4] The widespread use of ART has had the most profound influence on reducing OI-related mortality in HIV-infected persons in those countries in which these therapies are accessible and affordable.[5,7] Worldwide, it is estimated that between 250,000 and 350,000 deaths were averted in 2005 as a result of increased treatment access.[4] However, OIs continued to cause morbidity and mortality in HIV/AIDS patients even after receiving ART. This mortality occurs because some patients do not have a sustained response to antiretroviral agents for multiple reasons including poor adherence, drug toxicities, drug interactions, or initial acquisition of a drug-resistant strain of HIV-1.[8,9]

Despite the fact that different studies have been conducted on the prevalence of individual OIs among HIV-infected patients on ART in Ethiopia, information about the magnitude and spectrum of OIs is scarce in eastern Ethiopia. Therefore, this study tried to assess the prevalence of OIs and identify associated factors in patients taking ART drugs in Hiwot Fana Specialized University Hospital, Eastern Ethiopia.

Materials and methods

Study area, design, and period

Harari People's National Regional State is located in the Eastern part of the Ethiopia, which is 515 kilometers away from the capital city Addis Ababa. It had a projected total population of 203,438 people in the year 2010. There are six hospitals and eight health centers in the region (Harari Peoples' National Regional State health bureau, unpublished data, 2010). The health service coverage of the region is estimated to be about 100%. An ART program was launched on March 26, 2006 in the region. Hiwot Fana Specialized University Hospital, which is one of the hospitals in the region providing ART services to HIV/AIDs patients, began providing these services in March 2006. Until March 2014, a total of 3,290 HIV/AIDS patients have utilized ART services at this hospital.

A hospital-based, retrospective study was conducted in Hiwot Fana Specialized University Hospital ART clinic from April to June 2014. A total of 358 study participants were selected by systematic random sampling using the ART registration book as a sampling frame, and these patients' clinical records were reviewed.

Data collection methods

Data were collected by using a checklist, which was adopted from the hospital's clinical record format for monitoring HIV/AIDS patients on ART. Information on patients' details, such as socio-demographic characteristics, functional status, type of OIs, prophylaxis usage, and baseline WHO clinical staging, CD4 count cell count, hemoglobin level, and weight were retrieved from clinical records of the HIV/AIDS patients by trained nurses. Those patients' clinical records that were not complete or were missing data were omitted and were replaced with the next patient's record on the list. The data collection format was checked for its completeness and consistency with the patient's clinical records by a supervisor and the investigators on a daily basis.

Data entry and analysis

Data were double entered into a data entry file using SPSS software Version 16 and were analyzed according to the different variables. Results were presented by using mean, standard deviation (SD), and simple frequency tables with percentages. The prevalence of OIs was determined as the proportion of HIV/AIDS patients on ART who developed one or more OIs. Univariate and multivariate analysis logistic regression models were used to describe the significance of association between prevalence of OIs between selected variables. Crude and adjusted odds ratios (CORs and AORs, respectively) with 95% confidence intervals (CIs) were used to describe the strength of association between the selected study variables. The criterion for significance was set at $P<0.05$ based on a two-sided test.

Ethical considerations

The study protocol was approved by Institutional Health Research and Ethical Review Committee of the College of Health and Medical Sciences, Haramaya University, Harar, Ethiopia. The patients' clinical records were reviewed anonymously, and all information obtained from clinical records was kept confidential.

Results

Socio-demographic and clinical characteristics of the study participants

A total of 358 HIV/AIDS patients' ART records were reviewed in the current study. The mean age of study participants was 34 (SD ±9.8) years and ranging from 18–71 years. Most of the patients were in the age group of 30–39 years (41.4%), were female (68.4%), urban (83%), and had an elementary school education (44.7%). Many study participants (150, or 41.9%) were at WHO clinical stage III. Concerning functional status, most (65.9%) of patients were working personnel. The majority (75.7%) of the participants were receiving cotrimoxazole, while 14.5% were receiving isonicotinylhydrazine (INH) prophylaxis. About 69% of participants had a CD4 count <200 cells/mm^3. In addition, about 19.8% and 67% of participants had <10 mg/dL hemoglobin level and weighed <60 kg, respectively (Table 1).

Table 1 Socio-demographic and clinical characteristics of the study participants (n=358) at Hiwot Fana Specialized University Hospital ART Clinic, Harar, Eastern Ethiopia, 2014

Variables	Number	Percent
Sex		
Male	113	31.6
Female	245	68.4
Marital status		
Single	58	16.2
Married	160	44.7
Divorced	72	20.1
Widowed	68	19.0
Educational status		
Illiterate	58	16.2
Primary school (1st–8th grade)	160	44.7
Secondary school (9th–12th grade)	108	30.2
College/university	32	8.9
Residence		
Urban	297	83.0
Rural	61	17.0
Age group, years		
18–29	117	32.7
30–39	148	41.4
40–49	66	18.4
≥50	27	7.5
WHO stage		
I	70	19.6
II	95	26.5
III	150	41.9
IV	43	12.0
Functional status		
Working	236	65.9
Ambulatory	99	27.7
Bedridden	23	6.4
OI prophylaxis		
Cotrimoxazole	271	75.7
INH	52	14.5
Baseline CD4 cell count, cells/mm^3*		
<200	245	69
≥200	110	31
Baseline hemoglobin level, g/dL*		
<10	46	19.8
≥10	186	80.2
Baseline weight, kg		
<60	240	67
≥60	118	33

Note: *Percentage was not calculated for total study participants (358), due to missing values.

Abbreviations: ART, antiretroviral therapy; OI, opportunistic infection; WHO, World Health Organization; INH, isonicotinylhydrazine.

Prevalence of OIs

Out of 358 patients, 172 had diagnosed OIs, yielding an overall prevalence of 48% (172/358). There were a total of 185 OIs diagnosed in the 172 patients. About 44.7% (160/358), 3.1% (11/358), and 0.3% (1/358) of the study participants had single, dual, and triple OIs, respectively. The most frequent OIs were TB at 21.23% (76/358), Herpes zoster at 11.2% (40/358), and oral candidiasis at 9.5% (34/358) (Table 2).

Risk factors of OIs

The prevalence of OIs among males (48.7%) and females (47.8%) was comparable. The highest prevalence of OIs was found in those individuals in the age group of 30–39 years old (52.0%), with secondary school educational level (57.4%), rural dwellers (52.5%), and with body weight ≤60 kg (50.0%). However, the prevalence of OIs was not statistically different among the above variables ($P>0.05$).

In univariate analysis, study participants in WHO clinical stages III and IV were more likely develop OIs compared to those participants at WHO clinical stages I (COR =2.926; 95% CI =1.913, 5.768 and COR =3.654; 95% CI =2.476, 7.592, respectively). Those participants with CD4 cell counts of <200 cells/mm^3 were more likely develop OIs than their counterparts with higher CD4 cell counts (COR =1.878; 95% CI =2.070, 3.298). Participants who were bedridden (COR =7.901; 95% CI =5.457, 10.217) and ambulatory (COR =4.441; 95% CI =3.687, 7.012) were more likely to develop OIs compared to patients at work during initiation of ART. In addition, participants who were not on cotrimoxazole and INH prophylaxis were more likely develop OIs (COR =1.712; 95% CI =1.348, 2.758) compared to their counterparts who were on cotrimoxazole prophylaxis (Table 3).

In order to determine the independent predictors of OIs, WHO clinical stages, CD4 cell count, functional status of patients at the beginning of ART, participants receiving

Table 2 Prevalence of opportunistic infections among HIV/AIDS patients on ART at Hiwot Fana Specialized University Hospital ART Clinic, Harar, Eastern Ethiopia, 2014

Opportunistic infections	Frequency n (%)
Herpes zoster	38 (10.6%)
Bacterial pneumonia	7 (2%)
Tuberculosis	65 (18.2%)
Oral candidiasis	27 (7.5%)
Ulcers – mouth, genital	1 (0.28%)
Chronic diarrhea	13 (3.6%)
Pneumocystis carini pneumonia	3 (0.8%)
CNS toxoplasmosis	5 (1.4%)
Cryptococcal meningitis	1 (0.28%)
Bacterial pneumonia and tuberculosis	3 (0.8%)
CNS toxoplasmosis and Herpes zoster	1 (0.28%)
Oral candidiasis and tuberculosis	7 (2%)
Tuberculosis, Herpes zoster, and chronic diarrhea	1 (0.28%)

Abbreviations: ART, antiretroviral therapy; CNS, central nervous system; n, number of patients.

cotrimoxazole and INH prophylaxis, educational status, hemoglobin levels, and body weight were included in multivariate analysis, as they all had $P<0.25$ on univariate analysis. In addition, age and sex were also included in multivariate analysis due to the consideration of associated risk of OI in prior studies.[10,11]

Those participants in WHO clinical stage IV were about four times (AOR =3.856; 95% CI =2.691, 10.390) and participants in WHO stage III were about three times (AOR =2.801, 95% CI =1.958, 7.165) more likely develop OIs compared to those in WHO clinical stage I. Participants with CD4 cell counts of <200 cells/mm^3 were about two times (AOR =1.645; 95% CI =2.187, 3.983) more likely develop OIs compared to those with CD4 cell counts ≥200 cells/mm^3. Those participants who were not on prophylaxis were about two times (AOR =1.912; 95% CI =1.444, 3.824) more likely develop OIs than those who were on prophylaxis. Those HIV/AIDS patients who were bedridden were eight times (AOR =7.812; 95% CI=4.676, 9.421) and those who were ambulatory four times (AOR =4.464; 95% CI =3.647, 6.845) more likely develop OIs when compared with patients at work.

Discussion

The current study assessed the prevalence and associated factors of OIs among HIV-positive patients taking ART. The current study found that about 48% of HIV/AIDS patients on ART had one or more OIs. This finding was comparable to the 47.6% reported in a study conducted in Taiwan.[12] However, it is higher than two recent, similar studies carried out in Ethiopia in Gondor and Debre Markos, which documented 19.7% and 33.3% prevalence, respectively.[11,13] This difference might be due to variation of the degree of host immunity and methodological differences in selecting study subjects. These studies were conducted among HIV patients taking ART for 5 and more years. The risk of developing an OI for a person receiving ART is highest during the initial month of therapy.[14] Cohort studies carried out in Senegal[15] and Taiwan[12] also reported a decline of 79% in OIs among their cohorts during the 4th year of ART and 39% after 12 months of initiation of ART, respectively.

There were 12 co-infections of different OIs observed in the current study. Of these, 58.3% (n=7/12) were TB and oral candidiasis co-infections. This finding is in agreement with a report from Gondar, Ethiopia, which reported 50% TB and oral candidiasis co-infections.[13] A higher proportion of TB and oral candidiasis co-infection in the current study might be explained by a higher prevalence of these two OIs among the study participants. Dual and triple OIs were also reported from studies conducted in Debre Markos, Ethiopia and Nigeria.[11,16]

Mycobacterium tuberculosis is the leading cause of morbidity and mortality among people living with HIV worldwide. In Ethiopia, the co-infection rate is 20%–50%, creating a dual epidemic of symptomatic HIV infection and TB. TB enhances progression of HIV infection by inducing immune activation. In addition, HIV increases the risk of infection as well as reactivation of latent TB. Hence, it is conceivable that TB can occur across the clinical spectrum of HIV infection.[1]

The present study also revealed that TB infection is the predominant OI identified, with a prevalence of 21.23% (76/358). This was comparable with a study conducted in Taiwan in which the prevalence of TB-related OIs was found to be 18.2%.[12] However, it was higher than the prevalence reported from two areas in Ethiopia (9.7%) and Nigeria (7.7%), which also revealed TB as a major OI.[11,13,16] The rate was also lower compared to a TB prevalence of 34.5% previously reported in ART-naïve, HIV-infected patients in Bahir Dar, Ethiopia.[17] This might possibly be explained by methodological differences in selecting study subjects and the prevalence of TB in the general population.

Following TB, Herpes zoster and oral candidiasis were the second and the third most prevalent OIs in the present study, at 11.2% (40/358) and 9.5% (34/358), respectively. The prevalence of candidiasis was in agreement with a report from Debre Markos, Ethiopia and a report from Nigeria in which prevalence rates of 11.8% and 8.6% were noted, respectively.[11,16] The prevalence of Herpes zoster is in agreement with study carried out in India, which reported

Table 3 Univariate analysis factors associated with opportunistic infections (OIs) among HIV patients taking antiretroviral therapy (ART) at Hiwot Fana Specialized University Hospital ART Clinic, Harar, Eastern Ethiopia, 2014

Variables	OI		COR (95% CI)	*P*-value
	Yes	No		
Sex				
Male	55 (48.7%)	58 (51.3%)	1	0.473
Female	117 (47.8%)	128 (52.2%)	0.582 (0.386, 0.891)	
Marital status				
Single	26 (44.8%)	32 (55.2%)	1	0.823
Married	80 (50.0%)	80 (50.0%)	0.452 (0.331, 0.587)	
Divorced	32 (44.4%)	40 (55.6%)	0.781 (0.584, 0.965)	
Widowed	34 (50.0%)	34 (50.0%)	0.647 (0.421, 0.842)	
Educational status				
Illiterate	28 (48.3%)	30 (51.7%)	1	0.084
Primary	70 (43.8%)	90 (56.2%)	0.677 (0.548, 0.856)	
Secondary	62 (57.4%)	46 (42.6%)	0.813 (0.633, 1.025)	
College and above	12 (37.5%)	20 (62.5%)	0.923 (0.789, 2.653)	
Residence				
Urban	140 (47.1%)	157 (52.9%)	1	0.091
Rural	32 (52.5%)	29 (47.5%)	0.566 (0.325, 0.837)	
WHO stage				
I	4 (5.7%)	66 (94.3%)	1	0.001
II	39 (41.1%)	56 (58.9%)	1.629 (1.261, 2.513)	
III	102 (68.0%)	48 (32.0%)	2.926 (1.913, 5.768)	
IV	27 (62.8%)	16 (37.2%)	3.654 (2.476, 7.592)	
OI prophylaxis given**				
Yes	139 (49.6%)	141 (51.4%)	1	0.024
No	41 (52.6%)	37 (47.4%)	1.712 (1.348, 2.758)	
Baseline CD4 cell count, cells/mm^3				
<200	132 (53.9%)	113 (46.1%)	1.878 (2.070, 3.298)	0.026
≥200	40 (36.4%)	70 (63.6%)	1	
Functional status				
Working	95 (40.3%)	141 (59.7%)	1	0.030
Ambulatory	60 (60.6%)	39 (39.4%)	4. 441 (3.687, 7.012)	
Bedridden	17 (73.9%)	6 (26.1%)	7.901 (5.457, 10.217)	
Age, years				
18–29	53 (45.3%)	64 (54.7%)	1	0.435
30–39	77 (52.0%)	71 (48.0%)	0.681 (0.490, 0.961)	
40–49	28 (42.4%)	38 (57.6%)	0.126 (0.021, 0.314)	
≥50	14 (51.9%)	13 (48.1%)	0.103 (0.018, 0.292)	
Baseline hemoglobin level, g/dL				
<10	18 (39.1%)	28 (60.9%)	1	0.134
≥10	93 (50.0%)	93 (50.0%)	0.537 (0.394, 0.797)	
Baseline weight, kg				
<60	120 (50.0%)	120 (50.0%)	1	0.176
≥60	52 (44.1%)	66 (55.9%)	0.243 (0.102, 0.453)	

Note: **OI prophylaxis included cotrimoxazole and/or INH.
Abbreviations: CI, confidence interval; COR, crude odds ratio; INH, isonicotinylhydrazine; WHO, World Health Organization.

prevalence of 14.7%.[18] This rate was higher than the 0.6% reported from Nigeria.[16] However, higher (30.7%) prevalence of Herpes zoster were reported in ART-naïve, HIV-infected patients in Bahir Dar, Ethiopia.[17] This difference might be due to methodological differences in selecting study subjects and the prevalence of Herpes zoster in the general population.

The hospital where this study was conducted initiates ART when the CD4 level of a patient falls below 200 cells/mm^3 of blood, which is far lower than the recommendation by WHO, which increase susceptibility of HIV-infected individuals to OIs. In the current study, HIV-infected patient with CD4 counts of <200 cells/mm^3 were more likely to develop OIs compared to those with CD4 counts of ≥200 cells/mm^3.

Table 4 Multivariate analysis for selected variables with occurrence of opportunistic infections (OIs) among HIV patients taking antiretroviral therapy (ART) at Hiwot Fana Specialized University Hospital ART Clinic, Harar, Eastern Ethiopia, 2014

Variables	OI		AOR (95% CI)	*P*-value
	Yes, n (%)	No, n (%)		
Sex				
Male	55 (48.7%)	58 (51.3%)	1	0.093
Female	117 (47.8%)	128 (52.2%)	0.382 (0.186, 0.529)	
Educational status				
Illiterate	28 (48.3%)	30 (51.7%)	1	0.071
Primary	70 (43.8%)	90 (56.2%)	0.545 (0.467, 0.936)	
Secondary	62 (57.4%)	46 (42.6%)	0.413 (0.321, 2.212)	
College and above	12 (37.5%)	20 (62.5%)	0.351 (0.218, 1.843)	
WHO stage				
I	4 (5.7%)	66 (94.3%)	1	0.001
II	39 (41.1%)	56 (58.9%)	1.706 (1.821, 3.952)	
III	102 (68.0%)	48 (32.0%)	2.801 (1.958, 7.165)	
IV	27 (62.8%)	16 (37.2%)	3.856 (2.691, 10.390)	
OI prophylaxis given**				
Yes	139 (49.6%)	141 (51.4%)	1	0.020
No	41 (52.6%)	37 (47.4%)	1.912 (1.444, 3.824)	
Baseline CD4 cell count, cells/mm^3				
<200	132 (53.9%)	113 (46.1%)	1.645 (2.187, 3.983)	0.023
≥200	40 (36.4%)	70 (63.6%)	1	
Functional status				
Working	95 (40.3%)	141 (59.7%)	1	0.012
Ambulatory	60 (60.6%)	39 (39.4%)	4.464 (3.647, 6.845)	
Bedridden	17 (73.9%)	6 (26.1%)	7.812 (4.676, 9.421)	
Age, years				
18–29	53 (45.3%)	64 (54.7%)	1	0.321
30–39	77 (52.0%)	71 (48.0%)	0.917 (0.719, 1.974)	
40–49	28 (42.4%)	38 (57.6%)	0.212 (0.132, 0.971)	
≥50	14 (51.9%)	13 (48.1%)	0.112 (0.021, 0.287)	
Baseline hemoglobin level, g/dL				
<10	18 (39.1%)	28 (60.9%)	1	0.112
≥10	93 (50.0%)	93 (50.0%)	0.620 (0.434, 0.972)	
Baseline weight, kg				
<60	120 (50.0%)	120 (50.0%)	1	0.137
≥60	52 (44.1%)	66 (55.9%)	0.132 (0.151, 0.533)	

Note: **OI prophylaxis included cotrimoxazole and/or INH.
Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; INH, isonicotinylhydrazine; WHO, World Health Organization.

This finding is concordant with other studies from Gondar, Ethiopia which reported that HIV-infected patients with CD4 counts of <200 cells/mm^3 were more likely to develop OIs compared to the reference group of patients with CD4 counts >350 cells/mm.[13] Other studies from India also reported high risk of developing OIs such as TB, *Pneumocystis jirovecii* pneumonia, and Cryptococcal meningitis among patients with CD4 counts <200 cells/mm^3.[18] This finding appears accurate, since CD4 cells play a central role in the activation of both humoral and cellular immune response to fight against infection. Hence, low CD4 count increases susceptibility to OIs.[1,13,19]

Participants with advanced WHO stages III and IV were four and three times more likely to develop OIs than those with a WHO stage of I, respectively. This finding is in agreement with two studies from Gondar and Debre Markos, Ethiopia.[11,13] The study conducted in Gondor reported that WHO clinical stages III and IV HIV-infected patients were 9.4 and 22.6 times more likely to develop OIs compared to those in clinical stage I, respectively. The study conducted in Debre Markos reported that patients with advanced WHO stages III and IV were more likely to develop OIs than those with a WHO stage of I. Similar finding were also observed in studies conducted in India, South Africa, and Nigeria, which reported that advanced clinical stage of the disease were significantly associated with development of OIs among patients on ART.[16,20,21]

In the current study, the prevalence of OIs in those participants who were not on prophylaxis was significantly

higher as compared to those who were on prophylaxis. This finding is in complete agreement with the study from Gondor, Ethiopia,[13] which reported that cotrimoxazole prophylactic use is significantly associated with development of OIs among patients on ART.

Limitations

Due to the fact that data were collected from patients' clinical records, important records of risk factors of OIs such as adherence rate to ART and prophylactic treatments was not found. The hospital where this study was conducted did not perform cultures for the diagnosis of OIs. Hence, the majority of the OIs were diagnosed clinically, which may have affected the diagnostic accuracy. Since the pre-ART burden of OIs among the patients in this study was not assessed, the rate of decline in the burden of HIV-related OIs due to ART could not be determined.

Conclusion

In this study, a high rate (48%) of OIs was observed. This suggests that OIs remain a challenge in patients receiving ART in Ethiopia. TB followed by Herpes zoster and candidiasis were the major OIs encountered by HIV-infected patients taking ART. Baseline CD4 cell count was <200 cells/mm^3, baseline WHO clinical stages III and IV, and prophylaxis usage were found to be strongly associated with prevalence of OIs. Therefore, interventions need to be designed to promote early HIV testing and early enrollment of HIV-infected individuals into ART services. Individuals who continue to have low CD4 cell counts while on ART should be aggressively evaluated for OIs, and practical efforts to optimize their immunological recovery should be made. Prophylaxis should be widely implemented in the routine management of people living with HIV, irrespective of ART use.

Acknowledgments

We acknowledge Haramaya University Research and Publication Office for budget allocation and Institutional Health Research and Ethical Review Committee of the College of Health and Medical Sciences, Haramaya University, for giving ethical clearance. We also thank all individuals who have in one way or other contributed to the completion of this research.

Author contributions

HM designed the study, participated in data collection, analysis, interpretation, and write-up, drafted the manuscript, and critically revised the manuscript. ZT participated in study design, participated in data collection, analysis, interpretation, and write-up, drafted the manuscript, and critically revised the manuscript. FW participated in data collection, analysis, interpretation, and write-up, drafted the manuscript and critically revised the manuscript. All authors read and approved the final manuscript.

Disclosure

The authors report no conflicts of interest in this work.

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