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Prevalence of Some Opportunistic Infections (OIs) and Co-infections among HIV-Infected Persons in Port Harcourt, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author IOO designed the study and wrote the protocol. Authors TIC, AMA, CCO and SAO managed the laboratory analyses and performed the statistical analysis of the study. Author IOO managed the literature searches and wrote the first draft of the manuscript. Author IOO supervised the whole study which, author HO used as part of her B.Sc. Project in the Department of Microbiology, University of Port Harcourt, Nigeria. All authors read and approved the final manuscript.

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ABSTRACT

Aim: HIV/AIDS continues to spread globally and remains a worldwide pandemic. Opportunistic infections (OIs) occur more and are severe in people living with HIV who have weakened immune systems, and co-infection is another major challenge because it affects the rate to which the disease progress to AIDS. In the present study, a total of 100 HIV positive patients were recruited and evaluated for the presence of common opportunistic infections (OIs) and co-infections among HIV-infected individuals in Port Harcourt, Nigeria.
Study Design: Cross-sectional study.

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Place and Duration of Study: Prime Medical Consultants in Port Harcourt, Nigeria, between June 2012 and July 2015.
Methods: A total of 100 HIV-infected individuals were recruited for this study (ages 1 to 70 years, 62 males and 38 females). Samples of blood, sputum, high vaginal swabs (HVS) and scrapped lesion from the mouth of the patients were collected. Blood samples were re-screened for the presence of HIV antibodies and HBsAg using the Determine HIV-1/2 (Alere), HIV ½ Stat-Pak (Chembio), HIV-1/2/P24/O ELISA kit and HBsAg one Ultra ELISA kit (Dia.Pro) following the respective manufacturer's instructions. The Ziehl-Neelsen sputum smear microscopy method was used for identifying tuberculosis (TB). Microscopical examination was done on HVS samples and lesions scrapings from the mouth to observe for *Candida.* Chi-square test was used to establish relationships between demographic factors and prevalence, and significance level was set at $P \leq 0.05$.
Results: Of the 100 HIV positive patients, suspected case were 32.0% of TB, 28.0% of oral thrush and vaginosis, and 19.0% of hepatitis. The results of the laboratory analysis further showed that tuberculosis was the most common OI among others. Overall prevalence was 22.0% for TB, 11.0% for *Candida albicans* (oral thrush), 28.9% for *Candida albicans* (vaginosis) and 4.0% for HBV. Higher prevalence of TB was observed in the age groups 41 years & above (35.7%, P=0.14) and in males (22.6%, P=0.86). As for *Candida albicans*, the higher prevalence was found in age groups 21-40 years (19.1%, P=0.03) and in females only (28.9%), and higher prevalence of HBV was found in age groups 41 years & above (9.1%, P=0.78) and in females (5.3%, P=0.61). None of the variables (age and sex) evaluated in this study was statistically associated (P>0.05) with TB, Candida and HBV prevalence.
Conclusion: The study has also shown that some opportunistic infections (candidiasis and Tuberculosis) and coinfections with HBV is prevalent among HIV infected individuals and this could largely be due to a compromised immune system as a result of the viral activities in the host cell. There is need therefore to routinely check for OIs and co-infections especially in the case of an immunocompromised individual. It is also imperative to note that the appropriate use of drugs against these OIs may be one of the strategies to extend the life span of AIDS patients. This will help to monitor how the disease progresses and its complications.

Keywords: HIV; HBV; TB; Candida albicans; prevalence; Nigeria.

1. INTRODUCTION

About 37.9 million persons live with the human immunodeficiency virus (HIV) globally, while about a quarter of this figure is in Africa [1]. Generally, upon getting infected with HIV, the course of the disease may be great, some progress rapidly into AIDs and death within a few years if left untreated [2]. This is further complicated with the presence of Hepatitis B virus (HBV), as results from countries with highly active antiretroviral therapy (HAART) suggest liver diseases associated with HBV play a major role in deteriorating health and increasing the mortality rate in persons living with HIV [2,3]. The frequency of HIV is now becoming pandemic in our world, most especially developing countries such as Nigeria. Co-infection is another major challenge because it affects the rate to which the disease progress to AIDS [4].

The risks of developing many HIV-related diseases depends on how suppressed the patient's immunity is [5]. Opportunistic infections (OIs) occur more and are severe in people living with HIV who have weakened immune systems [6]. Presently, OIs are less frequent than they were in the initial days of HIV, because better treatments are available to lessen the amount of HIV in a person's body and maintain a stronger immune system. Nevertheless, a lot of people with HIV go on to develop OIs because they may be unaware, they are infected and not be on treatment, or their treatment may not be adequately reducing their HIV levels in order for their immune system to fight off infections [6].

Opportunistic infections have been identified as one of the existing causes that exacerbate the state of HIV-infected patients. Of these, parasites play a significant role as OIs as they are one of the most common causes of morbidity and mortality in HIV/AIDS patients [7]. Therefore, it is imperative that people with HIV be familiar with the most common OIs to ward them off or obtain treatment for them as early as possible, while working with their healthcare provider [6].

Tuberculosis (TB) remains one of today's global health challenges, ranking as the second leading infectious cause of death and one of the most burden-inflicting diseases in the world [8]. It is one of the top 10 causes of death and the leading cause from a single infectious agent (above HIV/AIDS) [9]. The 2019 WHO Global Tuberculosis Report estimated 1.5 million people deaths from TB in 2018 (including 251 000 people with HIV) and 10 million people were infected of TB worldwide [9]. HIV and Tuberculosis (TB) are the two main global public health threats that dent development in low and middle-income countries [4]. There is a well-established relationship between HIV and Tuberculosis (which is a transmissible infection that usually attacks the lungs) [10]. These two diseases are regularly referred to as co-epidemics (or dual epidemics) due to their high rate of co-infection [11-13]. According to the 2017 Global TB Report, Nigeria falls under the 14 high burden countries for TB, TB/HIV and MDR-TB, placing 7th among the 30 high TB burden countries that account for 80% of the global incidence of TB [11-13] and second in Africa [13]. For every hour, 47 Nigerians develop active TB, seven of whom are children and 18 Nigerians die from TB [13].

Despite the major impact made by introducing antiretroviral therapy (ART) on the infectious complications of AIDS, candidiasis remains a common opportunistic infection in people living with HIV [5]. Oropharyngeal candidiasis is the most prevalent opportunistic infection by fungi in HIV-infected individuals and is usually the first sign of HIV infection [5]. Prior to active antiretroviral therapy becoming available, oropharyngeal Candidiasis was commonly found in patients with HIV/AIDS, but are reported less as effective antiretroviral drugs were developed [5]. The greatest risk factor for the development of oropharyngeal candidiasis was cited to be a low absolute CD4+ T-lymphocyte count. As such, current guidelines suggest an increased risk when the CD4+ T lymphocyte counts decrease beneath 200 cells/μL [14,15].

Viral hepatitis is also a serious public health concern that affects billions of people globally [16]. More than 240 million people have HBV globally, and the majority occur in developing countries [16,17], such as Nigeria. Of the total number of persons living with HIV, about 7.4% are co-infected with HBV while 1% of persons living with HBV are also infected with HIV [18]. Both viruses share certain epidemiological characteristics, with HBV hinted to fasten the progression of HIV, even to AIDS [2,19].

This study sought to investigate the prevalence of some opportunistic infections (OIs) and co-infections among HIV-infected persons in Port Harcourt, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Patients attending Prime Medical Consultants (PMC) in Port Harcourt, Nigeria who were positive for HIV were enrolled for the study. Port Harcourt with Coordinates: 4°53'23"N 6°54'18"E, is found along the Bonny River in the Niger Delta region of Nigeria. The metropolis is made up of Obio/Akpor Local Government Area and Port Harcourt Local Government Area [20], which bears mostly the Ikwere ethnic group, with several other ethnic groups from all around Nigeria. From 2006 census report, Port Harcourt city local government area and Obio/Akpor local government area population of 1,382,592 and 878,890 respectively [21] and a landmass of 360 km^2 and 260 km^2 respectively.

2.2 Study Design

This is a cross-sectional study involving 100 HIV patients living with HIV and attending Prime Medical Consultants (PMC) in Port Harcourt, Nigeria. Blood withdrawal by venipuncture. Screening for suspected opportunistic infections (OIs) and co-infections, clinical evaluation and recording of demographic information's such as the age of the participants; marital status occupation, address etc.

2.3 Determination of Sample Size for the Study

The sample size for this study was determined using the established formula [22,23]: $N= [Z^2 (PQ)]/d^2$. Where N is the desired sample size. Z = standard normal deviation at a 95% confidence interval (which was 1.96). p = proportion of target population (prevalence estimated at 6.0%, reported for Rivers State as at HIV Sentinel Survey of 2010); this implies 6.0/100 = 0.06. q = alternate proportion (1-p), which was calculated as: 1 – 0.06 = 0.94. d = desired level of precision (degree of precision/significance). This was taken as 0.05. Then, the desired sample size (N) = 87. Hence, the estimated sample size was 87 individuals with an additional 10.0% sample

(which is 8.7) to take care of study participants that may be lost to follow-up [22,23], providing a total sample size of 96 approximated to 100.

2.4 Study Population

A total number of 100 clinical samples were collected from HIV positive patients attending Prime Medical Consultants (PMC) in Port Harcourt, Nigeria. The demographic details related to the study were obtained.

2.5 Inclusion and Exclusion Criteria

All HIV-infected patients were eligible for the study. HIV-infected patients who were duly documented in the registration book were included, whereas HIV-infected patients who had incomplete data like age, and duplicate records were excluded from the study. Those on any form of antibiotics were also excluded from the study.

2.6 Specimen Selection and Collection

The various specimens used were collected depending on the patient's symptoms and clinical features. About 3 ml of venipuncture blood was collected in EDTA BA Vacutainer TM anti-coagulant tubes (BD, Franklin Lakes, USA). Plasma specimens were separated by centrifugation at 300 rpm (revolution per minute) for 5 min. The plasma was stored at -20°C and used for the laboratory analyses. The specific clinical samples that were collected were high vaginal swab (HVS), sputum and scrapped lesion from the mouth of the patients.

2.7 Serological Analysis

Blood samples of HIV positive patients were collected by venipuncture method and re-screened for HIV antibodies using the Determine HIV-1/2, HIV ½ Stat Pak and ELISA Kit. Plasma was tested at the Virus Research Unit, Department of Microbiology, University of Port Harcourt, for the presence of antibodies to HIV following the respective manufacturer's instructions. HIV testing was done according to the national algorithm recommended by the Federal Ministry of Health of Nigeria. Rapid HIV tests: HIV (1 + 2) rapid test strips (Determine, Alere Co, LTD, Japan) as the screening test; and Stat-Pak (Chembio Diagnostic Systems, Inc., New York, NY, USA) as a confirmatory test for positive samples. These HIV testing methods were immuno-chromatographic assays. All samples with non-reactive results to HIV kits were considered negative. A commercially available HIV-1/2/P24/O ELISA kit (ELISA; Dia.Pro, Milano, Italy), was used as a tie-breaker. Positive and negative standard sera, accompanying the kit were included in each assay. Laboratory testing was carried out according to the manufacturers' instructions, and all tests were run using quality controls according to standard operating procedures.

2.8 Laboratory Analysis for Opportunistic Infections (OIs) and Co-Infections

Diagnosis of opportunistic infections involved routine microbiological smear microscopy and serological tests.

2.8.1 Microbiological analysis for tuberculosis

The Ziehl-Neelsen sputum smear microscopy method was used for identifying cases of tuberculosis (TB). In this process sputum sample was collected early in the morning in a sterile container, clean slides were labelled and used for each subject, an appropriate amount of sputum was placed on the slides using applicator sticks, smear preparation was made and allowed to air-dry for 15 minutes, this was heat fixed by passing through a Bunsen burner flame for three times, the slide was placed on a staining rack over a sink and then flooded with carbol fuchsine, the slide was gently heated with a flame and allowed to stain for 5mins, washed with water and decolourized with alcohol, the smears were counterstained with Loffler's methylene blue and left to stain for about 20 seconds, washed with water and allowed to air-dry, a drop of immersion oil was placed on the smear and viewed with the microscope. The examined specimens were classified as being either smear-positive or smear-negative. The smears that showed purple or reddish-pink rods were identified as AFB (acid-fast bacilli) meaning smear-positive results.

2.8.2 Microbiological analysis for candidiasis

Sample of vagina discharge was collected using sterile swab sticks; the discharge was placed on a slide and mixed with a solution of potassium hydroxide (KOH). The KOH eliminates bacteria and cells from the vagina, leaving only yeasts for easier detection of a yeast infection. The smear was viewed with the microscope and budding yeasts were characteristic findings, the same

method was used to examine the lesions scrapped from the mouth of some patients for the diagnosis of oral thrush.

2.8.3 Serological analysis of Hepatitis B Virus (HBV)

Laboratory diagnosis of HBV infection depends on the detection of hepatitis B surface antigen (HBsAg) in serum or plasma. A blood specimen was collected in EDTA bottles from all HBV patients, it was centrifuged for 5 minutes, the serum was taken using a plastic bulb pipette and place on the absorbent pad on the HBsAg test strip, the strip was left undisturbed for 5 minutes and observed visually for the results, the strips with the appearance of two pink lines were classified as positive and those with a single pink line were classified as negative. Also, an ELISA test was performed using HBsAg one Ultra ELISA kit (a commercially available kit produced by Dia.Pro. Diagnostic Bioprobes Srl., Milano, Italy) in accordance to the manufacturer's instructions. Briefly, the required numbers of strips were placed in the plastic holder and wash them once to hydrate wells. The wells for controls, calibrator and samples were carefully identified. Washing of the microwells was done using ELISA microplate washer (Model ELx50, BioTek Instruments, USA). The colour intensity of the solution in each well was measured using a 450 nm filter (reading) and a 630 nm filter, blanking the instrument on A1 using ELISA microplate reader (Model ELx808i, BioTek Instruments, USA). The test results were calculated using a cut-off value determined on the average OD450nm value of the negative control (NC) with the following formula: NC + 0.050 = Cut-Off (Co). Test results were interpreted following the kit manufacturer's instructions A negative result indicated that the patient is not infected by HBV and that the blood unit may be transfused. A positive result was indicative of HBV infection and therefore the patients should be treated accordingly.

2.9 Data Analysis

The seroprevalence was calculated. Chi-square test was used to establish relationships between demographic factors and prevalence using Microsoft Excel spreadsheet (Microsoft Corporation). Significance level was set at $P \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Participants characteristics

A total number of 100 clinical samples were collected from HIV positive patients attending Prime Medical Consultants (PMC) in Port Harcourt. Ages of participants ranged from 1-70 years, with the majority within the age group 21-40 years of age. There were 62 males and 38 females (Table 1).

3.1.2 Distribution of suspected cases of opportunistic infections (OIs) and coinfections

Of the 100 HIV positive patients, 32% had suspected cases of Tuberculosis, 28.0% had suspected cases of oral thrush and vaginosis while 19.0% had suspected cases of hepatitis. Table 2 shows the distribution of suspected cases of opportunistic infections (OIs) and coinfections.

3.1.3 Prevalence of Opportunistic Infections (OIs) and co-infections in HIV positive patients with their age and sex

Blood samples were collected and re-screened for HIV and HBV. Microbiological tests were also carried out for those with suspected opportunistic infections (OIs) and coinfections. Table 3 represents the results obtained. The overall prevalence of co-infections was 22.0% for HIV/TB, 11.0% for HIV/*Candida albicans* and 4.0% for HIV/HBV. Higher prevalence of HIV/TB co-infection was observed in the age group 41 years & above (35.7%) compared to other age groups and in males (22.6%) compared to the female counterparts (21.1%). As for HIV/*Candida albicans*, the higher prevalence was found among age groups 21-40 years (19.1%) compared to other age groups and among females only (28.9%). While for the HIV/HBV co-infections, the higher prevalence was also found among age groups 41 years & above (9.1%) compared to other age groups and in females (5.3%) compared to their male counterparts with 3.2% co-infection rates. Of all these co-infections, age was only statistically associated ($p=0.03$) with HIV/*Candida albicans* co-infections. (Table 3).

Table 1. Age and sex distribution of HIV positive patients

Variables	No. tested	Males (%)	Females (%)
Age Group (years)			
< 20	39	19 (48.7)	20 (51.3)
21 – 40	47	33 (70.2)	14 (29.8)
41 & above	14	10 (71.4)	4 (28.6)
Sex			
Males	62	62 (100.0)	Not Applicable
Females	38	Not Applicable	38 (100.0)
Total	100	62 (62.0)	38 (38.0)

Table 2. Distribution of suspected case of opportunistic infections (OIs) and co-infections in HIV positive patients

Infections	No. tested	No. of suspected cases (%)	No. positive (%)	Major causative agents
Tuberculosis	100	32 (32.0)	22 (22.0)	*Mycobacterium tuberculosis*
Oral thrush	100	28 (28.0)	11 (11.0)	*Candida albicans*
Vaginosis (females only)	32	32 (28.0)	11 (28.9)	*Candida albicans*
Hepatitis	100	19 (19.0)	4 (4.0)	Hepatitis B virus
Total	100	79 (79.0)	37 (37.0)	

Table 3. Prevalence of opportunistic infections (OIs) and co-infections in HIV positive patients with their age and sex

Variables	No. tested	No. positive for TB (%)	No. positive for *Candida albicans* (%)	No. positive for HBsAg (%)
Age Group (years)		**P=0.14***	**P=0.03****	**P=0.78***
< 20	39	4 (10.3)	0 (0.0)	1 (2.6)
21 – 40	47	13 (27.7)	9 (19.1)	2 (4.3)
41 & above	14	5 (35.7)	2 (18.2)	1 (9.1)
Sex		**P= 0.86***		**P=0.61***
Males	62	14 (22.6)	Not Applicable	2 (3.2)
Females	38	8 (21.1)	11 (28.9)	2 (5.3)
Total	100	22 (22.0)	11 (11.0)	4 (4.0)

*Key: * --- Not Significant, **--- Significant*

3.2 Discussion

Opportunistic infections are the major cause of death in HIV –infected individuals. In this study, the overall prevalence was found to be 22.0% for TB, 11.0% for *Candida albicans* (in oral thrush), 28.9% for *Candida albicans* (in vaginosis) and 4.0% for HBV, respectively.

3.2.1 Tuberculosis in HIV-infected individuals

The overall prevalence of HIV/TB co-infection reported in this study is higher than what was reported in our previous studies, 1.4% in Old Cross River State, Nigeria [4], 0.6% in Akwa Ibom State, Nigeria [4] and 1.2% in Cross River State, Nigeria [4]. Also, higher than the 17.6% reported in Itu, Akwa Ibom State, Nigeria [24]. However, it is lower than the 37.9% prevalence in Enugu State, Nigeria which is associated with an increasing prevalence rate of HIV/AIDS [25]. It is also lower than the 24.8% reported in Calabar, Nigeria [26] in a retrospective study and the 38.5% reported in Ikot Ekpene, Akwa Ibom State, Nigeria [24].

Age-specific prevalence of HIV/TB co-infection revealed a higher prevalence in the age group 41 years & above (35.7%) compared to other age groups. This is consistent with our previous findings in a similar study in Cross Rivers State, Nigeria which reported a higher prevalence in patients above 45 years of age [4]. This observation differs from our previous study [27]

in Port Harcourt, Nigeria which reported a higher prevalence in patients below 30 years. It also deviates from other related studies which reported HIV/TB co-infection is consistently high among the younger population [28,29].

Sex-specific prevalence of TB in HIV-infected individuals also revealed a higher prevalence in males (22.6%) compared to female counterparts (21.1%). This is not consistent with our earlier study which reported a higher prevalence in females than in males [4]. Lawson et al. [30] also were stated that females were more prone to HIV/TB co-infection than males. However, this outcome is in harmony with other previous studies, in Port Harcourt, Nigeria [27], in Calabar, Nigeria [26] and Ikot Ekpene, Akwa Ibom State, Nigeria [24]. Odaibo et al. [31] argued that gender does not play any significant role in the rate of HIV/TB coinfection.

3.2.2 *Candida albicans* in HIV-infected individuals

The mucocutaneous surfaces are colonized in the first step when candida infection develops [5,32]. HIV infection is not only associated with colonization rates increasing but also how the overt disease develops [5]. During HIV infection, the rate of Candida infection relates inversely to the CD4 counts of the patient which also depends on the use of antiretroviral treatment [5].

The present study analyzed the prevalence of Candida infection in these study participants. The prevalence of *Candida albicans* in this study is 28.9% (for vaginosis) and 11.0% (for oral thrush). It is lower than the 40.0% overall prevalence of *Candida albicans* and comparable with the 25.0% reported for *C. albicans* in HIV patients [15] in India. This is lower than the values reported in other previous studies. Anwar et al. [5] reported that oral candidiasis was the most common (71.25%) opportunistic fungal infection. Other various studies have reported a higher prevalence of candidiasis among HIV positive patients than what was obtained in the present study, 87.6% by Kalpesh et al. [33], 71.0% by Pruthvi et al. [34], 70.0% by Nagalingeswaran et al. [35], 65.0% by Singh et al. [36], 54.0% by Germain et al. [37], 50.0% by Anupriya et al. [38] and 37.8% by Rudramurthy [39]. Other studies reported comparable values for candidiasis in 23.0 to 27.0% of HIV positive patients [5,15,38,40,41]. Nevertheless, this value is greater than 16.65% reported by Shah et al. [42] in India.

The current prevalence rate of *C. albicans* in HIV patients in other parts of the world was 67.94% in Jamnagar [33], 66.4% in Sao Paulo, Brazil [43], 61.8% in Ethiopia [44], 82.2% in Iran [45], 74.8% in Germany [46], 54.8% in Hongkong [47], 87.0% in Southwest Uganda [48], 60.0% and 80.0%% in Nigeria [49,50] HIV patients.

In a similar study in Nigeria, 28.9% reported among HIV-infected females in our study is lower than the 34.4% reported by Enwuru et al. [51] in Lagos Nigeria. However, it is more than the 13.0% reported in high vaginal swab samples of HIV-infected patients [52], 12.5% reported by Okonkwo et al. [50] in Abakaliki, Nigeria and 9.68% reported by Lar et al. [53] from HIV infected individuals in Jos Nigeria. Also, the 11.0% reported among HIV-infected patients with oral thrush the is lower than the reported 56.3% in sputum samples [52] and the 30.7% in throat swab samples of HIV-infected patients [52].

As with other studies, *C. albicans* was the predominant *Candida* species obtained. This outcome agrees with studies by Thanyasrisuy et al. [54] and Costa et al. [55] who also reported *C. albicans* as the major Candida species commonly implicated in candidiasis among HIV patients. The low overall prevalence of oral Candida (11.0%) observed could be due to strict adherence of the patients to their antiretroviral regimen.

Age- and sex-specific prevalence *Candida albicans* in HIV-infected individuals showed a higher prevalence was found among age groups 21-40 years (19.1%) compared to other age groups and in females only (28.9%). This is consistent with what was reported previously. Ndukwu et al. [52] reported that the prevalence of candidiasis among HIV patients was higher among the ages of 26 – 33 years. Xavier and Auxilia [15] reported a higher prevalence among the age range of 31-40 years.

3.2.3 HIV/HBV co-infection

The 4.0% reported for HIV/HBV co-infection in this study is above the 2.0% reported in our previous study in Port Harcourt, Nigeria [2]. It is lower than the prevalence of 16.4% reported for the Niger Delta region [56], 30.9% in Abidjan, Cote d'Ivoire [16], 14.5% in Ghana [57], 0-15.0% in Sub Saharan Africa as notified in a retrospective review study [58]; even 22.3% in Ethiopia in a retrospective study of patients with chronic hepatitis [59].

Results from earlier studies showed that age proves to be the most vital factor in all epidemiological studies of HIV and HBV [56,60,61]. Age-specific HIV/HBV co-infections revealed a higher prevalence among age groups 41-60 years (9.1%) compared to other age groups. This was followed by age group 21-40 years (4.3%) and <20 years (2.6%). These findings were not consistent with similar work carried out in Nigeria which revealed the highest frequency of HIV/HBV in the age group 16-20 years [2] and 31-50 years [56]. This present finding deviates from that of Kouassi-M'Bengue et al. [16] who reported that age group of 16 to 55 years is the most affected compared to the older in Cote d'Ivoire. Makuwa et al. [62] reported a higher prevalence among young men in the same age group in urban areas of Gabon. Such disparity in HBV/HIV co-infection concerning age can be explained by the fact that most people are usually sexually active in the early part of their life.

Also, sex-specific HIV/HBV co-infections revealed a higher prevalence in females (5.3%) compared to their male counterparts (3.2%). This is also not consistent with similar work carried out in Nigeria which revealed that male HIV-infected patients were more infected with HBV than females [2,63]. This finding collaborated with some other studies in the country [56,60] which reported that females are more infected with HBV than males. This other studies in another part of the world. Kouassi-M'Bengue et al. [16] revealed that the seroprevalence of HBV among males is significantly higher than that found in females in their study. The present study is not consistent with the results obtained in China by Deng et al. [64] and in Gabon by Makuwa et al. [62]. There are no plausible explanations for the higher rate in males in these populations, however, it could probably be due to the higher exposure to occupational HBV risk factors in men, or else females clear the HBV more efficiently as compared to males [16].

This study equally has some limitations. Firstly, limited sample size and restriction to only one hospital, which makes the results not necessarily representative of the HIV-infected population of Rivers State, Nigeria. Another limitation is the cross-sectional design of this study which limits its capacity to establish causality, but we believe that these limitations did not significantly affect the final interpretation of study findings.

4. CONCLUSION

The present study has confirmed the prevalence of opportunistic infections (OIs) and co-infections is high among HIV-infected persons in Port Harcourt, Nigeria, with *Mycobacterium tuberculosis* (22.0%) as the leading cause of OIs and co-infections among others (*Candida albicans* 28.9% only in females, *Candida albicans* 11.0% in oral thrush and HBV, 4.0%). The study has also shown that candidiasis is prevalent among HIV infected persons and this could largely be due to a compromised immune system as a result of the viral activities in the host cell. There is need therefore to routinely check for OIs and co-infections especially in the case of an immunocompromised individual. It is also significant to note that the appropriate use of drugs against these OIs may be one of the strategies to extend the life span of AIDS patients. This will help to monitor how the disease progresses and its complications.

CONSENT

All authors declare that written informed consent was obtained from the patient (or other approved parties) for publication of this study.

ETHICAL APPROVAL

Administrative approval for this study was gotten from the management of Prime Medical Consultants (PMC) in Port Harcourt, Nigeria. Ethical considerations and approval for the study was sorted from the University of Port Harcourt Research Ethics Committee following the ethics for research involving human subjects. This study was carried out in line with the World Medical Association (WMA) Declaration of Helsinki on the principles for medical research involving human subjects, animal subjects and identifiable human/animal material/data. All authors hereby declare that all experiments have been examined and approved by the University Research Ethics committee of University of Port Harcourt, Nigeria and have, therefore, been performed following the ethical standards laid down in the 1964 Declaration of Helsinki.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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