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Prevalence and Factors Associated with Opportunistic Infections Among Adults with Advanced HIV Disease Attending a Tertiary Hospital in North-Central Nigeria: A Retrospective Cross-Sectional Study, 2023–2025

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Abstract

Background: Opportunistic infections (OIs) remain an important cause of morbidity among adults with advanced HIV disease (AHD). We assessed documented OIs and exploratory associations in a tertiary HIV clinic in North-Central Nigeria. **Methods:** This retrospective cross-sectional study reviewed targeted clinic records from 2023–2025. Of 150 records screened, 144 adults had documented CD4 counts <200 cells/µL and met eligibility criteria. OIs active at the index assessment or diagnosed within 14 days were counted. Crude prevalence ratios (PRs) and 95% confidence intervals (CIs) were estimated; no adjusted models were fitted. **Results:** Fifty-two participants had ≥1 documented OI (36.1%; Wilson 95% CI 28.7–44.2%), accounting for 65 diagnoses. Pulmonary tuberculosis (n=24), oral candidiasis (n=16), and recorded cryptococcal meningitis (n=9) predominated. OI prevalence was 62.5%, 40.9%, and 20.6% at CD4 counts <50, 50–99, and 100–199 cells/µL, respectively (trend P<0.001). ART-naïve participants had higher recorded OI prevalence than ART-experienced participants (PR 1.91; 95% CI 1.25–2.92). Among 89 ART-experienced participants with complete adherence data, poor versus good recorded adherence was associated with higher OI prevalence (PR 2.04; 95% CI 1.02–4.08), although the inference was sensitive to missing-data assumptions. **Conclusions:** Documented OIs were frequent in this selected hospital sample, especially at lower CD4 counts. Targeted selection, heterogeneous diagnostic certainty, confounding, and uncertain temporal ordering preclude population-wide or causal inference.

Keywords: advanced HIV disease; opportunistic infections; antiretroviral therapy; CD4 count; adherence; tuberculosis

Introduction

Advanced HIV disease (AHD) remains a major clinical concern despite wider access to antiretroviral therapy (ART). The World Health Organisation (WHO) defines AHD in adults and adolescents as a CD4 count <200 cells/µL or WHO clinical stage 3 or 4. Its recommended care package includes screening, prophylaxis or pre-emptive treatment, appropriate ART initiation or optimisation, and adherence support (World Health Organisation, 2017, 2025). AIDS-related conditions, particularly tuberculosis, continue to account for many hospital admissions among people living with HIV (Burke et al., 2025). The proportion of patients presenting with CD4-defined AHD varies across healthcare settings (Ford et al., 2025). AHD has also been documented in the African Cohort Study, which included Nigerian sites (Oboho et al., 2024), and mortality remains substantial

among affected adults in sub-Saharan Africa (Scheier et al., 2026).

Late presentation to HIV care has been reported in Nigeria (Agaba et al., 2014). Fungal infections contribute to AIDS-related illness in sub-Saharan Africa (Duvenage et al., 2025), while a Nigerian multicentre survey found asymptomatic cryptococcal antigenaemia among patients with advanced immunosuppression (Oladele et al., 2023). These findings support targeted diagnostic and preventive care for patients with AHD (Lehman et al., 2023). Clinical staging alone can miss immunologically defined AHD, making access to CD4 testing important (Twabi et al., 2026). Local data on recorded OIs in North-Central Nigeria could help services plan screening and prophylaxis.

The distinction between documented infection and systematically ascertained infection is particularly important in routine-care datasets. A patient may have a clinically significant illness without undergoing a pathogen-specific investigation, whereas another patient may receive a presumptive diagnosis because confirmatory testing is unavailable. Estimates from clinical records consequently reflect both the underlying burden of illness and the local pathways through which patients are assessed. Describing these pathways alongside the observed frequency of infections makes the findings more useful for clinical quality improvement and avoids implying that all patients underwent equivalent screening.

We estimated the prevalence and clinical spectrum of documented OIs among adults with CD4-defined AHD attending the Federal University of Health Sciences Teaching Hospital, Otukpo (FUHSTHO). We also examined unadjusted associations with age, sex, CD4 stratum, ART status, and recorded adherence.

Materials and Methods

Study Design and Setting

This retrospective cross-sectional study reviewed records of adults attending the specialised HIV clinic at FUHSTHO, Benue State, North-Central Nigeria, from 1 January 2023 to 31 December 2025. The clinic provides outpatient HIV care, ART, and referral for inpatient treatment to patients from Benue State and adjoining areas. During the study period, assessment for AHD included baseline CD4 measurement, serum cryptococcal antigen (CrAg) testing, urine tuberculosis lipoarabinomannan (TB-LAM) testing, GeneXpert MTB/RIF, and chest radiography. Test use depended on reagent availability and clinical indication.

The active clinic population comprised approximately 1,850 unique adults receiving care during the three years. The clinic used both paper and electronic records, which limited comprehensive electronic screening. Investigators searched appointment registers, laboratory logs, and clinical folders for suspected advanced disease, constitutional symptoms, or documented low CD4 counts. This search identified 150 records for assessment. Deceased, transferred, disengaged, and archived patients were not included in active-file screening. Duplicate record numbers and repeated encounters were checked, and each patient contributed only the first qualifying encounter.

The approximately 1,850 active clinic attendees represent the service population rather than a denominator for estimating the frequency of AHD or OIs across the clinic. The 150 records were selected through targeted identification of possible advanced disease; therefore, the fraction included cannot be interpreted as a screening yield from a random or consecutive cohort. The unit of analysis was the individual patient at the index encounter, not a clinic visit or an infection episode. This distinction prevents repeated consultations from inflating participant counts.

The study used a targeted sample of records rather than a census of the clinic population. Patients with asymptomatic or uninvestigated advanced disease may have been missed. Reporting was guided by STROBE, particularly its recommendations on participant selection, variable definitions, and study limitations (Vandenbroucke et al., 2007; von Elm et al., 2007).

Eligibility and Study Population

Patients were eligible if aged ≥18 years and had documented AHD during the study period. The eligibility definition followed WHO guidance: CD4 <200 cells/µL or WHO stage 3/4 (World Health Organisation, 2017). Patients were eligible regardless of OI status. Six of the 150 screened records lacked both eligibility variables and were excluded, leaving 144 for analysis.

The CD4 value nearest the index encounter within a ±30-day window was extracted. Historical values predating the study period were used only if verified as the current baseline assessment for a newly presenting patient. WHO stage was recorded from the treating clinician's assessment at the index encounter. Stage was not an additional selection requirement; every included patient had a documented CD4 count <200 cells/µL.

Two trained clinical investigators, O.A.E. and O.N.M., independently checked eligibility, extracted data, and verified coding against primary health records including clinic registers, laboratory logs, patient management charts, and detailed patient-level diagnostic records (including diagnostic test logs, sputum smear registers, radiology reports, and clinical progress notes). Five initially discrepant screened records (5/150, 3.3%) were reconciled by a third reviewer; discrepancies were resolved before analysis.

All 144 included records had CD4 counts below 200 cells/µL; no included record depended on clinical stage alone for eligibility. CD4 counts were <50 cells/µL in 32 participants, 50–99 in 44, and 100–199 in 68.

Index Assessment and Ascertainment Window

The index assessment was the first encounter during the study period at which AHD eligibility was established. An OI was linked to that encounter if it was active at presentation or diagnosed within the prespecified 14-day window for the same clinical episode. Active infections were those recorded as symptomatic or receiving acute treatment; resolved historical infections were excluded. For encounters in late December 2025, linked diagnostic results from the following 14 days in January 2026 were included. The outcome represents documented OI prevalence around one index assessment.

The 14-day linkage window was used to include investigations initiated at the index visit but completed shortly afterwards. It was not designed to measure new infection incidence over follow-up. Conditions documented outside that window were not included in the primary outcome merely because they appeared elsewhere in a patient's history. The same window was applied conceptually to participants with and without recorded infections, although completeness of investigation could not be assumed to be equal.

Outcome Definition and Diagnostic Certainty

The primary outcome was at least one documented OI linked to the index assessment. Diagnoses were accepted on the basis of the clinical, laboratory, microbiological, or imaging evidence recorded by treating clinicians. Laboratory confirmation was not required for every condition. Nonspecific diarrhoea without a documented infectious cause was excluded. Each affected participant was counted once in the prevalence estimate, while each distinct diagnosis was retained in the clinical-spectrum analysis.

Diagnostic evidence was classified as follows:

Pulmonary tuberculosis: Sixteen of the 24 recorded cases were microbiologically confirmed by GeneXpert MTB/RIF or sputum acid-fast bacilli smear. Eight were diagnosed from compatible clinical and chest radiographic findings. **Cryptococcal meningitis:** Five of the nine recorded cases had supporting CrAg or cerebrospinal fluid (CSF) India ink results, and four were clinical diagnoses based on meningeal signs and supporting evaluation. Serum antigenaemia alone does not establish meningitis. Because the summary did not identify the specimen for every CrAg result, CSF confirmation could not be established for every test-supported case. **Bacterial pneumonia:** The seven recorded cases were supported by a compatible clinical presentation, pulmonary consolidation on imaging, and purulent sputum or supportive leukocyte counts. These criteria distinguished the recorded diagnoses from upper respiratory tract infections. **Cerebral toxoplasmosis:** The four recorded cases were based on focal neurological deficits or compatible neuroimaging, together with positive Toxoplasma serology. **Pathogen-specific enteritis:** Two cases were retained because the records documented specific stool microscopy or culture findings. Investigators also searched for extrapulmonary tuberculosis, oesophageal candidiasis, Pneumocystis jirovecii pneumonia (PCP), and Kaposi sarcoma. None was documented within the index window. This could reflect diagnostic constraints, missing documentation, or absence of disease.

Clinical and presumptive diagnoses remained in their recorded categories. Routine records can miss infections or include incorrect presumptive diagnoses, so the direction of bias in the prevalence estimate is uncertain.

In particular, the cryptococcal meningitis category describes the diagnoses entered in clinical records, not nine uniformly cerebrospinal-fluid-confirmed episodes. The available aggregate evidence cannot establish whether every positive cryptococcal antigen result came from cerebrospinal fluid or serum. Similarly, radiological support for pulmonary tuberculosis is not equivalent to microbiological confirmation. Reporting these distinctions is essential because apparent differences in diagnostic frequency may reflect test access as well as disease occurrence.

Exposures and Missing Adherence Data

The exposure variables were age (18–35, 36–50, or >50 years), sex, CD4 stratum (<50, 50–99, or 100–199 cells/µL), ART status at the index date, and recorded adherence. Adherence was assessed only among ART-experienced participants, using pharmacy refill and pill-count records from the preceding three to six months. The observation period varied with scheduled collection intervals. Good recorded adherence was defined as ≥95% and poor adherence as <95%. Dispensing logs took precedence when refill and pill-count measures differed. Recent ART initiators with less than three months of treatment history were assessed from the dispensing records available.

Three of the 92 ART-experienced participants had incomplete refill or dispensing documentation: two were OI-positive and one was OI-negative. Their adherence was classified as unknown. The primary analysis included 89 participants with complete records: 58 with good adherence (11 OI-positive and 47 OI-negative) and 31 with poor adherence (12 OI-positive and 19 OI-negative). These classifications describe the clinic's recorded assessment. Refill coverage and pill counts do not directly measure medication ingestion.

Two sensitivity analyses assigned the three unknown records to poor adherence and to good adherence, respectively. These assignments tested the effect of missing-data assumptions; they did not establish actual adherence. WHO stage was described but not tested as an associated factor because some stage-defining conditions also contributed to the OI outcome.

Statistical Analysis

Categorical variables are presented as counts and percentages with their denominators. Overall, OI prevalence was calculated as 52/144, with a two-sided Wilson 95%

confidence interval (CI). Crude prevalence ratios (PRs) and Katz log-method CIs were the main association measures. Crude odds ratios (ORs) and Wald CIs were also reported. ORs and PRs should not be interpreted interchangeably when outcomes are common. Global associations were assessed with Pearson chi-square tests without continuity correction. Contrast-specific P values came from two-sided Wald tests of log ORs. The Cochran–Armitage trend test used scores of 1, 2, and 3 for CD4 strata <50, 50–99, and 100–199 cells/μL, respectively. Calculations used the contingency counts shown in the tables. The primary adherence analysis included complete records; the sensitivity analyses included all 92 ART-experienced participants under the stated assumptions.

Contingency-table statistics were recalculated from the reported aggregate counts. Analyses were exploratory and unadjusted; no multivariable model was fitted. The significance threshold was P <0.05, without adjustment for multiple testing. Interpretation considered the effect estimates, CIs, possible confounding, and sensitivity to missing-data assumptions.

Because only aggregate contingency counts were available for the reported analyses, joint distributions of CD4 stratum, ART status, adherence, and OI status were not used to estimate adjusted effects. A statistically significant crude comparison should therefore be regarded as a signal for further investigation rather than evidence that an exposure independently predicts infection. In addition, multiple exploratory comparisons increase the possibility of chance findings; no correction for multiplicity was applied. The adherence sensitivity analyses specifically address uncertainty from three missing classifications and do not address confounding or measurement error in the remaining adherence records.

Ethical Considerations

Initial ethical approval was obtained from the Federal University of Health Sciences Teaching Hospital Health Research Ethics Committee on 14 March 2023 (Ref: FUHSTH/HREC/2023/012). Following study protocol expansion, a formal institutional ethics extension was sought and approved on 10 December 2025 (Ref: FUHSTH/HREC/2023/012/EXT-01) prior to data extraction, permitting record reviews through 31 December 2025. An administrative confirmation of continued ethics compliance was subsequently issued on 12 January 2026. Data extraction was conducted between 15 January and 28 February 2026 in full alignment with institutional ethical approvals and documentary records. Individual informed consent was waived for review of existing records. Data were de-identified for analysis.

Results

Participant Flow and Prevalence

Targeted screening of appointment registers, laboratory logs, and clinical folders identified 150 records from an active clinic population of approximately 1,850 adults receiving care between 1 January 2023 and 31 December 2025. Following eligibility screening, six records lacked documentation of CD4 count or WHO clinical stage and were excluded, leaving 144 eligible adult participants with confirmed CD4-defined advanced HIV disease (<200 cells/μL) included in the final analysis. Among these 144 participants, 52 had at least one documented opportunistic infection linked to the index assessment, yielding an overall prevalence of 36.1% (Wilson 95% CI, 28.7–44.2%), while 92 participants had no documented opportunistic infection within the index assessment window (Figure 1).

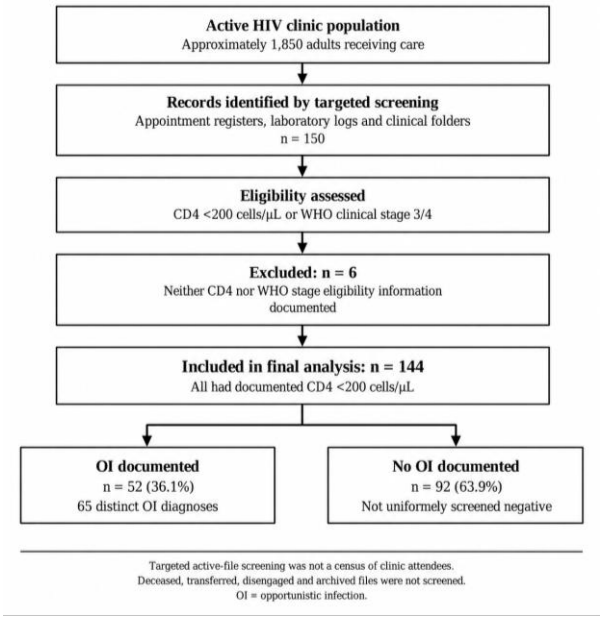


Figure 1. Participant selection and study flow, 2023–2025.

Targeted screening of active files was not a census of all clinic attendees. Deceased, transferred, disengaged, and archived files were not screened. OI, opportunistic infection.

Participant Characteristics

Participants aged 18–35 years formed the largest age group (43.1%), and 54.2% were female (Table 1). All participants were recorded as WHO stage 3 (61.1%) or stage 4 (38.9%). Stage 4 accounted for 57.7% of OI-positive and 28.3% of OI-negative participants. Recorded stage-defining conditions among OI-negative participants included severe chronic wasting and recurrent bacterial infections outside the study's OI classification. Stage distributions are descriptive because stage and OI definitions can overlap.

Of the 92 ART-experienced participants, 58 had good recorded adherence, 31 had poor adherence, and three had

unknown adherence. Complete adherence records were available for 23 OI-positive and 66 OI-negative participants. Table 1 includes the unknown category in the descriptive adherence counts.

Table 1. Participant characteristics by documented opportunistic infection status

Characteristic	Category	Overall N = 144	OI present n = 52	OI absent n = 92
Age, years	18–35	62 (43.1)	21 (40.4)	41 (44.6)
	36–50	56 (38.9)	22 (42.3)	34 (37.0)
	>50	26 (18.1)	9 (17.3)	17 (18.5)
Sex	Female	78 (54.2)	25 (48.1)	53 (57.6)
	Male	66 (45.8)	27 (51.9)	39 (42.4)
CD4 count, cells/µL	<50	32 (22.2)	20 (38.5)	12 (13.0)
	50–99	44 (30.6)	18 (34.6)	26 (28.3)
	100–199	68 (47.2)	14 (26.9)	54 (58.7)
ART status	ART-naïve	52 (36.1)	27 (51.9)	25 (27.2)
	ART-experienced	92 (63.9)	25 (48.1)	67 (72.8)
Recorded ART adherence*	Good (≥95%)	58 (63.0)	11 (44.0)	47 (70.1)
	Poor (<95%)	31 (33.7)	12 (48.0)	19 (28.4)
	Unknown	3 (3.3)	2 (8.0)	1 (1.5)
WHO stage†	Stage 3	88 (61.1)	22 (42.3)	66 (71.7)
	Stage 4	56 (38.9)	30 (57.7)	26 (28.3)

Values are n (column %). All variables except adherence use the column-header denominators. Adherence percentages use all ART-experienced participants: 92 overall, 25 with OI, and 67 without OI, including unknown adherence. The primary association analysis excludes the three unknown records (n=89). WHO stage is descriptive; some stage-defining conditions overlap with the OI outcome. Rounding may affect percentage totals.

Clinical Spectrum

The 52 OI-positive participants had 65 recorded diagnoses. Forty-one had one infection, nine had two, and two had three (41 + 18 + 6 = 65). Pulmonary tuberculosis and oral candidiasis were the most common diagnoses (Table 2).

Pulmonary tuberculosis was recorded in 24 participants (46.2% of OI-positive participants; 16.7% of the full sample), oral candidiasis in 16 (30.8%; 11.1%), cryptococcal meningitis in nine (17.3%; 6.3%), and bacterial pneumonia in seven (13.5%; 4.9%). Other diagnoses were cerebral toxoplasmosis, herpes zoster, and infectious enteritis. Table 2 reports both denominators and the supporting diagnostic evidence.

These diagnosis-specific proportions describe different quantities from overall participant prevalence. For example, the tuberculosis proportion among OI-positive patients indicates its contribution to the observed case mix. In contrast, the corresponding percentage of all 144 participants describes its recorded frequency in the selected study sample. The sum of diagnosis counts exceeds the number of affected individuals because we retained concurrent infections separately. Consequently, the diagnostic categories should not be added to estimate the proportion of patients affected.

Table 2. Recorded opportunistic infections and supporting diagnostic evidence

Recorded diagnosis	Diagnostic evidence recorded	N	% of OI-positive (n/52)	% of full sample (n/144)
Pulmonary tuberculosis	GeneXpert MTB/RIF or sputum AFB smear (16); clinical–radiological diagnosis (8)	24	46.2	16.7
Oral candidiasis	Clinical inspection and/or lesion testing	16	30.8	11.1
Cryptococcal meningitis	CrAg/CSF India ink support recorded in 5; clinical diagnosis in 4. CrAg specimen detail incomplete in the summary.	9	17.3	6.3
Bacterial pneumonia	Microbiological and/or compatible clinical–radiological evidence	7	13.5	4.9
Cerebral toxoplasmosis	Recorded clinical diagnosis with neurological, imaging, and/or serological support; certainty heterogeneous	4	7.7	2.8
Herpes zoster	Characteristic dermatomal lesions	3	5.8	2.1
Pathogen-specific enteritis	Stool microscopy/culture	2	3.8	1.4
Total diagnoses	Includes concurrent active OIs	65	—	—

Diagnosis-specific percentages among OI-positive participants may exceed 100% because participants can have multiple infections. The 52 OI-positive participants had 65 diagnoses: 41 had one, nine had two, and two had three. Clinical and presumptive diagnoses are retained as recorded; the combined CrAg summary does not establish CSF confirmation for every test-supported meningitis case. AFB, acid-fast bacilli; CrAg, cryptococcal antigen; CSF, cerebrospinal fluid.

Exploratory Unadjusted Associations

OI prevalence was 62.5% (20/32), 40.9% (18/44), and 20.6% (14/68) in the CD4 <50, 50–99, and 100–199 cells/μL strata, respectively (global Pearson P <0.001; trend P <0.001). Compared with 100–199 cells/μL, the PR was 1.99 (95% CI, 1.11–3.57) for 50–99 and 3.04 (95% CI, 1.77–5.20) for <50 cells/μL. Prevalence was higher in ART-naïve than ART-experienced participants (51.9% versus 27.2%; PR, 1.91; 95% CI, 1.25–2.92). No statistically significant association was detected for sex (global Pearson P =0.270) or age category (P =0.817). Table 3 reports the unadjusted estimates.

The absolute difference in recorded OI prevalence between the lowest and highest CD4 strata was 41.9 percentage points (62.5% minus 20.6%). This gradient is clinically notable but cannot by itself distinguish the effects of immunosuppression from differences in presentation, treatment history, or investigation intensity. Likewise, the observed ART-status comparison is a cross-sectional contrast at the index assessment; ART status and the recorded infection may have been influenced by prior care and clinical circumstances.

Table 3. Exploratory unadjusted associations with documented opportunistic infections

Variable	Category	OI + / −	Prevalence %	Crude PR (95% CI)	Crude OR (95% CI)	Wald P
CD4, cells/µL	100–199	14 / 54	20.6 (14/68)	1.00 (Reference)	1.00 (Reference)	—
	50–99	18 / 26	40.9 (18/44)	1.99 (1.11–3.57)	2.67 (1.15–6.19)	0.022
	<50	20 / 12	62.5 (20/32)	3.04 (1.77–5.20)	6.43 (2.55–16.23)	<0.001
ART status	ART-experienced	25 / 67	27.2 (25/92)	1.00 (Reference)	1.00 (Reference)	—
	ART-naïve	27 / 25	51.9 (27/52)	1.91 (1.25–2.92)	2.89 (1.42–5.90)	0.003
Adherence*	Good ≥95%	11 / 47	19.0 (11/58)	1.00 (Reference)	1.00 (Reference)	—
	Poor <95%	12 / 19	38.7 (12/31)	2.04 (1.02–4.08)	2.70 (1.02–7.16)	0.046
Sex	Female	25 / 53	32.1 (25/78)	1.00 (Reference)	1.00 (Reference)	—
	Male	27 / 39	40.9 (27/66)	1.28 (0.83–1.97)	1.47 (0.74–2.91)	0.271
Age, years	18–35	21 / 41	33.9 (21/62)	1.00 (Reference)	1.00 (Reference)	—
	36–50	22 / 34	39.3 (22/56)	1.16 (0.72–1.87)	1.26 (0.60–2.68)	0.542
	>50	9 / 17	34.6 (9/26)	1.02 (0.54–1.92)	1.03 (0.39–2.71)	0.946

PR, prevalence ratio (Katz CI); OR, odds ratio (Wald CI). Contrast-specific P values test log odds ratios. Global Pearson P values: CD4 <0.001; ART status 0.003; adherence 0.043; sex 0.270; age 0.817. CD4 trend P <0.001. Primary adherence analysis includes 89 participants: 23 OI-positive and 66 OI-negative. All estimates are unadjusted and exploratory.

In the primary complete-case adherence analysis, OI prevalence was 38.7% (12/31) with poor and 19.0% (11/58) with good recorded adherence (PR, 2.04; 95% CI, 1.02–4.08; OR, 2.70; 95% CI, 1.02–7.16; Wald P =0.046; global Pearson P =0.043).

When the three unknown adherence records were assigned to poor adherence, the PR was 2.17 (95% CI, 1.11–4.23; Wald P =0.023). Assigning them to good adherence gave a PR of 1.82 (95% CI, 0.94–3.50; Wald P =0.080). The estimated association remained in the same direction, but its statistical significance depended on the missing-data assumption (Table 4).

The complete-case comparison is based on 89 of 92 ART-experienced participants, and its confidence interval is wide. The two extreme assignments provide a transparent assessment of the three missing classifications rather than a probability-based imputation. Because the upper and lower scenarios yield different conclusions at the conventional significance threshold, the adherence result should be described as uncertain even though the estimated direction of association is consistent across scenarios.

Table 4. Sensitivity of adherence associations to missing data assumptions

Analysis	Poor adherence OI + / −	Good adherence OI + / −	Crude PR (95% CI)	Wald P	Pearson P
Complete records only (n=89)	12 / 19	11 / 47	2.04 (1.02–4.08)	0.046	0.043
All unknowns assigned poor (n=92)	14 / 20	11 / 47	2.17 (1.11–4.23)	0.023	0.021
All unknowns assigned good (n=92)	12 / 19	13 / 48	1.82 (0.94–3.50)	0.080	0.076

Three ART-experienced participants had unknown adherence: two OI-positive and one OI-negative. Assignments are hypothetical sensitivity assumptions. PRs use Katz log-method CIs; Wald P values test log odds ratios; Pearson P values use chi-square tests without continuity correction. Statistical significance depends on the missing-data assumption.

Discussion

More than one-third of adults with CD4-defined AHD in this selected sample had a documented OI. The estimate reflects infections recorded during routine hospital care. Patients with symptoms may have been investigated more extensively, and diagnostic assessment may also have differed by ART status. These differences could affect both the recorded prevalence and comparisons between groups.

The finding of 36.1% should therefore be understood as a proportion among specifically identified adults with documented CD4-defined AHD whose records were available for review. It is not an estimate of the prevalence among all adults living with HIV in Benue State, all attendees of the hospital HIV clinic, or all persons with advanced disease in the catchment area. A larger unselected cohort with a common diagnostic protocol would be required for those broader estimates.

Tuberculosis was the leading recorded diagnosis, consistent with its contribution to hospital admissions among people living with HIV (Burke et al., 2025). The nine recorded cryptococcal meningitis cases also draw attention to fungal disease in this setting (Duvenage et al., 2025). Nigerian evidence on asymptomatic antigenaemia supports cryptococcal screening in advanced immunosuppression (Oladele et al., 2023). The absence of recorded extrapulmonary tuberculosis or PCP cannot distinguish true absence from missed diagnosis or documentation. WHO clinical staging also has limited accuracy for identifying immunologically defined AHD, supporting access to CD4 testing (Twabi et al., 2026).

From a service-delivery perspective, the concentration of recorded OIs in patients with the lowest CD4 counts reinforces the value of prompt immunological assessment and timely evaluation for major infections. However, the study did not compare alternative screening strategies, evaluate diagnostic test accuracy, or measure treatment outcomes. Its findings cannot determine which screening pathway is most cost-effective or whether any intervention would reduce mortality in this clinic.

OI prevalence increased as CD4 counts fell. This pattern is consistent with the role of CD4 measurement in identifying advanced immunosuppression (Ford et al., 2017). ART-naïve participants also had a higher recorded OI prevalence. However, the unadjusted comparison may reflect differences in CD4 count, presentation, treatment duration, and diagnostic assessment. The study cannot establish an independent effect of ART status or a causal relationship.

The adherence finding requires particular caution. In the complete-case analysis, the PR was 2.04, but its lower confidence limit was close to 1. Assigning the missing records to good adherence produced a CI that included 1. The conclusion therefore depends on assumptions about missing data. Evidence linking adherence to virologic outcomes provides clinical context (Bezabhe et al., 2016), but does not establish that poor adherence caused the OIs recorded here. Acute illness may disrupt medication access or refill attendance, and attendance records do not establish whether medication was taken.

Adherence records are also susceptible to reverse temporal interpretation. Symptoms from an evolving infection could have preceded a missed refill, while poor treatment engagement could have occurred earlier and contributed to immunosuppression. Without reliably dated measures of medication exposure, viral load, and infection onset, these explanations cannot be separated. This uncertainty is especially relevant when using the word “associated,” which here refers only to a cross-sectional statistical relationship.

Strengths and Limitations

The study included patients without a recorded OI, distinguished participant prevalence from diagnosis counts, and reported the evidence supporting diagnoses. Contingency counts allow readers to recalculate the crude estimates. Unknown adherence was excluded from the primary analysis and examined under alternative classifications.

Some limitations affect interpretation. The single-centre design and targeted screening of active files limit representativeness. Excluding deceased, transferred, disengaged, and archived patients may introduce survivor bias. Test availability and investigation intensity may have differed between groups. Clinical and presumptive diagnoses can lead to either missed or incorrectly classified infections. Adherence observation periods varied, and the chronology of exposure and infection could not always be established. The analyses did not account for CD4 count, treatment duration, or other potential confounders simultaneously. Complete-case analysis may also be biased if missing documentation relates to illness or treatment engagement. The findings concern recorded infections around one index episode and do not estimate population prevalence, incidence, or independent causal effects.

Further limitations include the modest number of OI-positive participants within individual categories, which reduces precision for subgroup comparisons. Clinical stage was not treated as an independent exposure because several stage-defining conditions overlap with the infection outcome; analysing it as a predictor would risk circular interpretation. The study also cannot establish how frequently negative tests were performed, so a record without an OI diagnosis is not equivalent to a comprehensive negative infectious-disease assessment.

The results support continued attention to OI assessment within the WHO AHD care package (World Health Organization, 2017, 2025). The 2025 guidance informs current service recommendations; it does not establish that the updated package was implemented throughout the study period. Prospective studies should document exposure and diagnostic dates, specimen-specific evidence, and adherence measures, and prespecify the confounders to be included in adjusted analyses.

Future research should ideally enroll consecutive patients with AHD, retain information on deaths and transfers, document the dates and specimens underlying diagnoses, and distinguish confirmed from presumptive infections. Collecting viral-load measurements, ART initiation dates, and longitudinal adherence data would support more credible assessment of temporality. Such studies could estimate adjusted associations with prespecified confounders and assess whether standardized diagnostic pathways improve ascertainment and patient outcomes. In the present clinic, the most defensible immediate implication is to review the completeness and consistency of AHD assessment and documentation, rather than to infer treatment effects from the observed crude associations.

Conclusions

Documented OIs affected more than one-third of adults with CD4-defined AHD in this selected hospital sample. Pulmonary tuberculosis, oral candidiasis, and recorded cryptococcal meningitis were the most frequent diagnoses. Lower CD4 counts and ART-naïve status were associated with OIs in unadjusted analyses. Poor recorded adherence was associated with OIs in the complete-case analysis, but the finding was sensitive to missing-data assumptions. Selection bias, diagnostic uncertainty, confounding, and unclear temporal ordering limit causal and independent predictive interpretation.

Abbreviations

AFB: acid-fast bacilli; **AHD:** advanced HIV disease; **ART:** antiretroviral therapy; **CD4:** cluster of differentiation 4; **CI:** confidence interval; **CrAg:** cryptococcal antigen; **CSF:** cerebrospinal fluid; **FUHSTHO:** Federal University of Health Sciences Teaching Hospital, Otukpo; **OI:** opportunistic infection; **OR:** odds ratio; **PCP:** Pneumocystis jirovecii pneumonia; **PR:** prevalence ratio; **STROBE:** Strengthening the Reporting of Observational Studies in Epidemiology; **TB-LAM:** tuberculosis lipoarabinomannan; **WHO:** World Health Organization.

Ethics approval and consent to participate

Initial ethical approval was obtained from the Federal University of Health Sciences Teaching Hospital Health Research Ethics Committee on 14 March 2023 (Ref: FUHSTH/HREC/2023/012). Following study protocol expansion, a formal institutional ethics extension was sought and approved on 10 December 2025 (Ref: FUHSTH/HREC/2023/012/EXT-01) prior to data extraction, permitting record reviews through 31 December 2025. An administrative confirmation of continued ethics compliance was subsequently issued on 12 January 2026. Data extraction was conducted between 15 January and 28 February 2026 in full alignment with institutional ethical approvals and documentary records. Individual informed consent was waived for review of existing records. Data were de-identified for analysis.

Availability of data and materials

The de-identified record-level dataset supporting the conclusions of this article is available from the corresponding author upon reasonable request and institutional approval.

Competing interests

The authors declare no competing interests.

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Authors' contributions

Otache Adah Emmanuel, Ocheifa Ngbede Matthew, and Stephen O. Abah conceived the study. Otache Adah Emmanuel and Ocheifa Ngbede Matthew collected the data. Otache Adah Emmanuel, Emmanuel Amaechi Nwobi, Catherine Adebiyi, and Ntat Charles Ibiok performed statistical analysis. All authors interpreted data, drafted the manuscript, and approved the final version.

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Declaration on the Use of Generative AI

Generative AI tools (ChatGPT, OpenAI) were used to assist with language editing, manuscript organization, reference formatting, and preparation of code for aggregate-data checks. The authors reviewed and verified the resulting content and retain full responsibility for the accuracy, integrity, scientific interpretation, and final manuscript.

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