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Determinants of Success of Antiretroviral Therapy in HIV/AIDS Patients: A Viral Load-Based Study in Bekasi Regency, 2023-2024

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Abstract

Background: *HIV/AIDS remains a significant global public health issue. Antiretroviral therapy (ART) is the cornerstone of HIV care, with viral load suppression being critical for treatment success. However, multiple factors influence ART outcomes. This study aimed to identify factors associated with negative ART outcomes (non-success), specifically focusing on viral load suppression among HIV/AIDS patients in the Bekasi Regency, Indonesia.*

Method: *A cross-sectional analysis was conducted using secondary data from the HIV/AIDS Information System (SIHA) at the Bekasi Regency Health Office, extending from January 2023 to September 2024. Data from 811 patients on ART were analyzed through univariable, bivariable and multivariable steps to identify factors associated with viral load suppression.*

Result: *Most patients (87.3%) achieved viral load suppression (≤50 copies/mL). Poor Adherence to Appointment (Adjusted Prevalence Ratio [PR]: 5.27; $p < 0.001$), advanced clinical severity stage (Adjusted PR: 2.52; $p < 0.001$), and use of TLD regimen (Adjusted PR: [missing value]; $p = 0.001$) were significant predictors of unsuppressed viral load. Patients with PLHIV partners had a 1.27 times greater risk of experiencing unsuppressed viral load (Adjusted PR: 1.27; $p = 0.004$).*

Conclusion: *ART success in the Bekasi Regency is influenced by Adherence of appointments, clinical stage, ARV regimen type, and partner HIV status. These findings are crucial for informing national and global HIV/AIDS control strategies, emphasizing the importance of enhancing adherence, early ART initiation, and individualized ARV regimens.*

Keywords*: Adherence of appointment, ARV therapy success, Clinical stage, People living with HIV/AIDS, Viral load*

INTRODUCTION

HIV remains a major global public health issue, having claimed an estimated 40.4 million [32.9–51.3 million] lives to date, with ongoing transmission reported in all countries worldwide. Some countries have even reported increasing trends of new infections.[1] HIV and AIDS are serious health conditions that require widespread public understanding. Human Immunodeficiency Virus (HIV) is a virus that weakens the immune system, while Acquired Immune Deficiency Syndrome (AIDS) is an advanced condition characterized by severe immune system deterioration caused by HIV infection.[2] Over the past 25 years, HIV infection has rapidly expanded from isolated cases within certain populations to widespread transmission across all regions and countries globally. This ongoing problem

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demands urgent attention, as evidenced by the significant annual increase in reported AIDS cases. The World Health Organization (WHO) is committed to eliminating AIDS by 2030, embodied in the "Three Zero" targets: zero new HIV infections, zero AIDS-related deaths, and zero stigma and discrimination against people living with HIV/AIDS (PLHIV).[3] In line with WHO's goals, the Indonesian Ministry of Health has set a 95-95-95 target: 95% of PLHIV know their HIV status; 95% of those diagnosed receive antiretroviral (ARV) therapy; and 95% of those on ARV therapy achieve viral load suppression.[4] Based on SIHA data as of January 2024, Indonesia's progress towards these targets by the end of 2023 shows that 393,921 PLHIV (76%) are alive and aware of their status, 177,277 (45%) of these are receiving ARV treatment. Among those treated, 82,046 (46%) have achieved viral load suppression.[5]

The primary goal of antiretroviral therapy (ART) is to suppress HIV replication to levels where drug-resistance mutations cannot develop. Although evidence is inconclusive, data suggest that drug-resistance mutations rarely occur in patients who maintain persistent viral suppression. Currently recommended ARV regimens for initial therapy that use TLD (Tenofovir, Lamivudine, and Dolutegravir) have a high probability of achieving viral suppression in patients. TLD is a more recent, highly recommended regimen, often used as a first-line treatment, compared to TLE (Tenofovir, Lamivudine, and Efavirenz) was previously the standard regimen. However, patients failing to meet treatment goals or experiencing virologic rebound may develop resistance mutations to one or more components of their regimen. Adherence to ARV regimens can be challenging, and poor adherence is strongly linked to detectable viral loads.[6] The study by Thamrin et al. revealed that all HIV patients who adhered to ARV therapy had undetectable viral loads (100%), whereas 80% of those with poor adherence exhibited detectable viral loads. This indicates that high adherence to ARV medication plays a crucial role in reducing the viral load in HIV-infected patients.[7] To achieve the third "95" target set by the WHO, 95% of all people receiving ART achieve viral suppression, and optimal and sustained care is essential. In Indonesia, where an estimated 600,000–650,000 people live with HIV, approximately 570,000 of them are receiving ART.[1]

Unsuppressed viral load can result from multiple factors. Cohort data from the early era of combination ART use indicated that suboptimal adherence and drug intolerance/ toxicity were major contributors to virologic failure and treatment discontinuation.[6] Factors associated with viral load levels in HIV patients include sociodemographic variables (age, sex, education, marital status), clinical conditions (opportunistic infections, clinical stage, body mass index (BMI), comorbidities, neurological disorders), treatment-related factors (ARV regimen type, adherence to appointments, duration of treatment), and patient-related factors such as key population status and partner HIV status. Research on HIV in Bekasi Regency is still limited to handling HIV and AIDS, both in terms of clinical and service. Given the importance of the HIV issue in the world and especially in Indonesia, viral load suppression is an important component of it. Researchers are interested in researching determinants of the success of antiretroviral therapy in HIV/AIDS patients: viral load-based study in Bekasi Regency, 2023-2024.

METHOD

This study used secondary data obtained from the HIV/AIDS Information System (SIHA) at the Bekasi Regency Health Office, covering the period from January 2023 to September 2024. A descriptive-analytic method with a cross-sectional study design was applied. The source population consisted of all individuals diagnosed with HIV/AIDS in Bekasi Regency during the study period (n=2,026). The inclusion criteria were patients who had received ART and had complete viral load test results. The inclusion criteria were patients on ART for less than six months (n=280), those without peer support (n=449), and those who did not undergo viral load testing within the study timeframe (n=289). After applying these criteria, 1,008 patients were initially eligible. Subsequently, 197 patients were excluded due to incomplete medical records, yielding a final sample of 811 patients. The sample size was calculated using the formula for comparing two proportions, assuming a 95% confidence level (Z_1–$\alpha/2 = 1.96$), 90% power (Z_1–$\beta = 1.28$), and equal sample size in both groups. The expected proportions of exposure (i.e., poor adherence) were P1 = 0.75 among cases (with virological failure) and P2 = 0.25 among controls (without failure), based on previous research. These assumptions resulted in a minimum sample size of 27 subjects. To improve statistical power and account for potential confounding, we included the entire eligible population, resulting in a final sample of 811 patients.

As part of the effort to maintain the internal validity of the study, the researchers planned a more comprehensive bias mitigation strategy. This effort included identifying and controlling for potential selection bias through an analysis of the characteristics of patients excluded due to incomplete data to assess the possibility of systematic differences that could have influenced the results. In addition, the researchers planned to conduct sensitivity analyses to test the robustness of the model, for example by re-evaluating the results using alternative definitions for key variables and including borderline variables that were previously eliminated in the model selection process.

This study did not include interaction analysis between independent variables in the multivariable model. The primary objective was to identify the main effects associated with viral load suppression, and the available sample size may have limited the statistical power to detect interaction effects. Future studies with larger sample sizes are recommended to explore potential interactions between predictors.

Measurements and Procedures

The primary outcome was viral load suppression, classified as suppressed (viral load ≤50 copies/mL) or unsuppressed (viral load >50 copies/mL). The viral load suppression cut-off used in this study was defined as ≤50 copies/mL, while values >50 copies/mL were classified as unsuppressed. This threshold is based on internationally recognized clinical guidelines from the U.S. Department of Health and Human Services (DHHS) and the WHO, which consider plasma HIV RNA levels of ≤50 copies/mL as the standard definition for virologic suppression in patients receiving antiretroviral therapy (ART).[6,8] Viral load below this limit is indicative of effective viral suppression and reduced risk of HIV transmission and drug resistance. Independent variables included sociodemographic factors (age, sex, education level, marital status), clinical factors (opportunistic infections, clinical stage, body mass index, comorbidities, neurological disorders), treatment factors (ARV regimen type, Adherence to appointments, duration of treatment), and partner's HIV status. Data was extracted directly from the SIHA database and anonymized. Data cleaning was conducted to remove incomplete records, ensuring data validity and reliability.

Statistical Analysis and Ethical Clearance

Data was analyzed using STATA version 17 (Serial Number: 18461036). Descriptive univariate analysis characterized the study population. Bivariate analysis using Chi-Square tests evaluated associations between independent variables and viral load suppression, reporting crude prevalence ratios (PR) with 95% confidence intervals. Variables with p-values <0.25 in bivariate analysis were included in multivariable analysis. In this study, we applied Cox Regression with a constant time approach in the context of a cross-sectional analysis to estimate PR rather than Hazard Ratios. This modified use of Cox Regression is well-established as an alternative to logistic regression when the outcome is common (i.e., prevalence >10%) and when estimating PR is preferred over Odds Ratios, which tend to overestimate effect sizes in such scenarios.[9] Our approach is supported by previous methodological studies that recommend Cox Regression with constant risk time as a valid method to approximate PRs in cross-sectional data settings. Cox Regression was performed to calculate adjusted prevalence ratios (Adjusted PR) and identify independent predictors of viral load suppression. Patients' identifiers were removed to maintain confidentiality. Ethical approval was obtained from the Ethics Committee of the Faculty of Public Health, Universitas Indonesia (Approval Number: Ket-210/UN2.F10. D11/PPM.00.02/2025).

RESULTS

A total of 811 HIV/AIDS patients undergoing antiretroviral therapy at health facilities in Bekasi Regency from January 2023 to September 2024 were included in the study. From the initial 2,026 patients, those who had been on therapy for more than six months, received peer support, and had viral load test results were selected. A total of 197 patients were excluded due to missing education data. The flow diagram illustrates the selection process from the source population to the final sample. Only patients with complete key variables were included in the analysis.

Univariate analysis showed that most patients (87.3%) achieved viral load suppression, defined as ≤50 copies/mL. Regarding adherence to ART appointments, 58.0% of patients demonstrated good adherence. Demographically, more than half of the patients (53.5%) were younger than 35 years, and a

substantial majority were male (75.5%). Educational attainment was generally low, with 91.7% of patients having lower levels of education. Clinically, 57.8% of patients were at advanced clinical stages

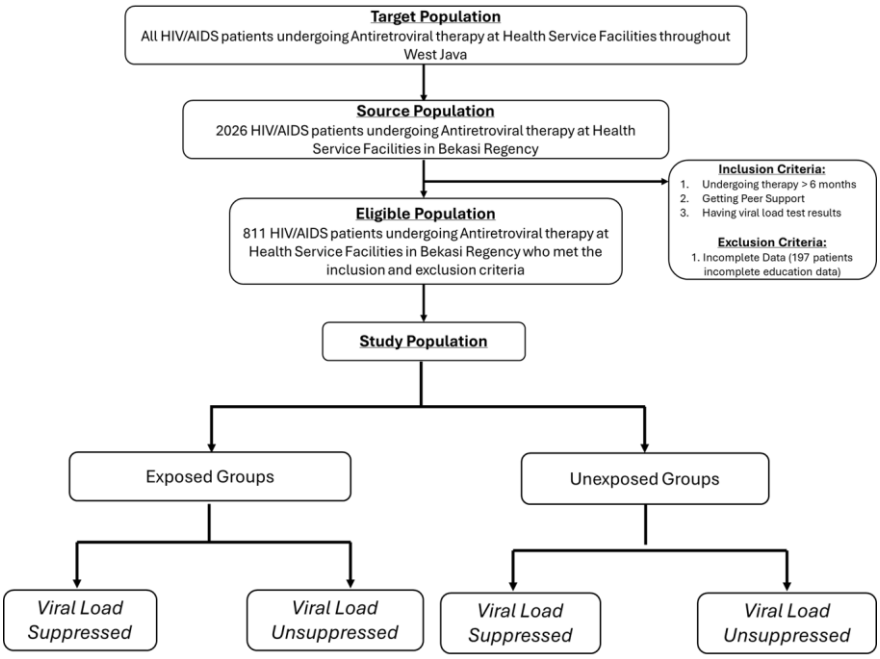

Figure 1. Research Sample Selection and Determination Flow

(stage 3 or 4) at the time of data collection. Most patients (76.3%) had been on ART for between 1 and 5 years.In terms of ART regimen, 56.2% were receiving the TLD (Tenofovir, Lamivudine, Dolutegravir) regimen, 39.1% the TLE (Tenofovir, Lamivudine, Efavirenz) regimen, and 4.7% other regimens. Key populations represented 45.9% of the study sample, including female sex workers (FSW), men who have sex with men (MSM), transgender individuals, and drug users. Nutritional status assessment showed that 44.4% of patients were overweight or obese, while 42.5% had a normal body mass index (BMI). The prevalence of neurological disorders and comorbidities was relatively low, at 2.6% and 3.6%, respectively. Most patients (59.7%) reported they did not have a partner, while 14.1% had a partner who was also living with HIV (PLHIV).

Table 2 presents the results of the bivariate analysis, highlighting several variables significantly associated with the success of antiretroviral (ARV) therapy based on viral load levels. Patients who were non-adherent to their medication regimen had a 5.72-fold higher risk of experiencing unsuppressed viral load, as compared to those who were adherent (Crude Prevalence Ratio [PR]: 5.72; 95% Confidence Interval [CI]: 3.59–9.13; $p < 0.001$). Patients at advanced clinical stages exhibited a greater risk of unsuppressed viral load than those at early stages (Crude PR: 2.05; 95% CI: 1.35–3.11; $p < 0.001$). Furthermore, the use of TLE and other ARV regimens was associated with better viral load suppression compared to the TLD regimen (Crude PR: 0.52; 95% CI: 0.34–0.79; $p < 0.001$). Additional variables, including marital status and partner's HIV status, also demonstrated statistically significant associations with viral load suppression.

The candidate variables of individual multivariate analysis were adherence to appointments, marital status, opportunistic infections, clinical stage, duration of treatment, ARV regimen, BMI, comorbidities, and partner HIV status. A backward elimination approach was used for selection. LR test: Likelihood Ratio Test was used to test how appropriate the model was. The final model results for multivariate analysis showed four variables that had significant influence in assessing the success of ARV therapy, namely: adherence to appointment (Adjusted PR: 5.27; $p = 0.000$), clinical stage (Adjusted PR: 2.52; $p = 0.000$), ARV regimen (Adjusted PR: 0.52; $p = 0.001$) and partner HIV status (Adjusted PR: 1.27; $p = 0.004$). These findings suggest that patients who are non-compliant, are in advanced clinical stages, use TLD/TLE ARV Regimens, and have partners with HIV-positive status

have a higher risk of experiencing unsuppressed Viral Load, while patients who use other ARV Regimens have a greater chance of suppressing Viral Load (Table 3).

Table 1. Distribution of Characteristics of HIV Patients Undergoing ARV Treatment

Variable	Frequency (N)	Percentage (%)
Viral Load		
Suppressed	708	87.3
Not Suppressed	103	12.7
Adherence of Appointment		
Good Adherence	470	58.0
Poor Adherence	341	42.0
Age		
< 35 Years	434	53.5
≥ 35 Years	377	46.5
Gender		
Male	612	75.5
Female	199	24.5
Education		
Higher	67	8.3
Lower	744	91.7
Marital Status		
Married	285	35.1
Single	526	64.9
Opportunistic Infections		
No IOs	302	37.2
Yes, 1 IOs	452	55.7
Yes, 2 IOs	46	5.7
Yes, >2 IOs	11	1.4
Clinical Stage		
Early Stage	342	42.2
Advanced Stage	469	57.8
Duration on ART		
1—5 Years	619	76.3
> 5 Years	192	23.7
ARV Regimen		
TLD	456	56.2
TLE	317	39.1
Other Regimen	38	4.7
Population Group		
Not Key Population	439	54.1
Key Population (FSW, MSM, TG, Drug Addict)	372	45.9
Body Mass Index		
Normal	345	42.5
Underweight	106	13.1
Overweight & Obesity	360	44.4
Neurological Disorders		
No	790	97.4
Yes	21	2.6

Table 1. Distribution of Characteristics of HIV Patients Undergoing ARV Treatment

Variable	Frequency (N)	Percentage (%)
Comorbid		
No	782	96.4
Yes	29	3.6
Partner's HIV Status		
Don't Have Partner	484	59.7
HIV Status Unknown	134	16.5
Not PLHIV	79	9.7
PLHIV	114	14.1

Table 2. Determinants of ARV Therapy Success Based on Viral Load Levels in HIV/AIDS Patients in Bekasi Regency in 2023–2024

Variable	Viral Load				P – value	Crude PR 95% CI
	Suppressed		Un-suppressed			
	N	%	N	%		
Adherence of Appointment						
Good Adherence	450	95.7	20	4.3		Ref
Poor Adherence	258	75.7	83	24.3	<0.001	5.72 (3.59—9.13)
Age						
< 35 Years	379	87.3	55	12.7		Ref
≥ 35 Years	329	87.3	48	12.7	0.979*	1.00 (0.69—1.44)
Gender						
Male	534	87.3	78	12.7		Ref
Female	174	87.4	25	12.6	0.946*	0.98 (0.64—1.50)
Education						
Higher	59	88.1	8	11.9		Ref
Lower	649	87.2	95	12.8	0.845*	1.06 (0.54—2.10)
Marital Status						
Married	239	83.9	46	16.1		Ref
Single	469	89.2	57	10.8	0.030	0.67 (0.47—0.96)
Opportunistic Infections						
No IOs	271	89.7	31	10.3		Ref
Yes, 1 IOs	389	86.1	63	13.9	0.138	1.36 (0.91—1.03)
Yes, 2 IOs	39	84.8	7	15.2	0.309	1.48 (0.69—3.17)
Yes, >2 IOs	9	81.8	2	18.2	0.388	1.77 (0.48—6.48)
Clinical Stage						
Early Stage	315	92.1	27	7.9		Ref
Advanced Stage	393	83.8	76	16.2	<0.001	2.05 (1.35—3.11)
Duration on ART						
1—5 Years	535	86.4	84	13.6		Ref
> 5 Years	173	90.1	19	9.9	0.181	0.73 (0.45—1.17)

Table 2. Determinants of ARV Therapy Success Based on Viral Load Levels in HIV/AIDS Patients in Bekasi Regency in 2023–2024

Variable	Viral Load				P-value	Crude PR 95% CI
	Suppressed		Un-suppressed			
	N	%	N	%		
ARV Regimen						
TLD	382	83.8	74	16.2		Ref
TLE	290	91.5	27	8.5	0.002	0.52 (0.34—0.79)
Other Regimen	36	94.7	2	5.3	0.106	0.32 (0.08—1.27)
Population Group						
Not Key Population	387	88.2	52	11.8		Ref
Key Population	321	86.3	51	13.7	0.426*	1.16 (0.80—1.66)
Body Mass Index						
Normal	295	85.5	50	14.5		Ref
Underweight	89	84.0	17	16.0	0.694	1.11 (0.67—1.83)
Overweight & Obesity	324	90.0	36	10.0	0.071	0.69 (0.46—1.03)
Neurological Disorders						
No	691	87.5	99	12.5		Ref
Yes	17	81.0	4	19.0	0.376*	1.52 (0.62—3.74)
Comorbid						
No	685	87.6	97	12.4		Ref
Yes	23	79.3	6	20.7	0.188	1.67 (0.79—3.48)
Partner's HIV Status						
Don't have partner	438	90.5	46	9.5		Ref
HIV Status Unknown	112	83.6	22	16.4	0.023	1.73 (1.08—2.76)
Not PLHIV	65	82.3	14	17.7	0.026	1.86 (1.08—3.23)
PLHIV	93	81.6	21	18.4	0.006	1.94 (1.21—3.11)

Table 3. Multivariate Model Determinants of Success of ARV Therapy Based on Viral Load Levels in HIV/AIDS Patients in Bekasi Regency in 2023–2024

Variable	β	P-value	PR	95% CI	
				Lower	Upper
Adherence of Appointment	1.66	<0.001	5.27	3.22	8.61
Clinical Stage	0.92	<0.001	2.52	1.61	3.95
ARV Regimen	-0.65	0.001	0.52	0.35	0.77
Partner's HIV Status	0.24	0.004	1.27	1.08	1.49

A sensitivity analysis was conducted to assess the robustness of the multivariable model to variations in key parameters and assumptions. The results confirmed the stability of the model estimates, with no significant changes observed in the direction or strength of associations. These findings indicate that the main conclusions of the study are not sensitive to the modifications tested.

DISCUSSION

This study has several limitations that should be acknowledged. First, the use of secondary data limits the availability of important behavioral variables such as treatment adherence, risk behavior, or stigma-related factors, which could act as unmeasured confounders and influence the outcome. Second, although data cleaning was performed, there remains a possibility of selection bias due to the exclusion of incomplete records, particularly related to education data. Additionally, the cross-sectional design limits the ability to establish temporal or causal relationships between exposure and outcome. These limitations may introduce bias in both directions and should be considered when interpreting the findings.

In terms of external validity, the findings of this study are primarily applicable to HIV/AIDS patients receiving antiretroviral therapy within the public health care system in Bekasi Regency. While the characteristics of the study population may reflect broader patterns seen in other urban or peri-urban regions of Indonesia, caution should be exercised when generalizing the results to different settings, such as rural areas or other countries with different healthcare infrastructures, socio-cultural dynamics, or treatment protocols. Further studies in diverse populations are needed to confirm the consistency of these findings.

Adherence to Appointment

This study identified poor adherence to appointments as the strongest predictor of unsuccessful viral load suppression among HIV/AIDS patients undergoing ART in the Bekasi Regency. Patients with poor adherence were 5.27 times more likely to have an unsuppressed viral load (Adjusted PR: 5.27; $p < 0.001$), consistent with findings from Thamrin et al. and Martinez, which emphasize that high adherence is critical to achieving virologic suppression.[7,10] Poor adherence is influenced by various interrelated factors, including boredom in taking medication for life, side effects of medication such as dizziness and nausea, being busy and forgetting to take medication, long distance to health facilities, high social stigma, and economic constraints such as difficulty in paying for insurance or transportation. [11]

WHO recommends adherence rates exceeding 95% for effective viral suppression. Although the 95% adherence threshold has long been cited as originating from an earlier study using the Patient-Centered HIV Care Model (PCHCM), it was found that viral suppression in 90% of patients could be achieved at an overall adherence level of 82%. Given the lifelong need for ART and common barriers like stigma and treatment fatigue, clinicians should continue promoting “every dose every day” messaging. Patient-centred counselling, peer support programs, digital reminders, and community-based interventions remain essential strategies to sustain long-term adherence and prevent drug resistance.[12] Additionally, integrating mental health services into HIV care, as suggested by Santos, can address comorbid depression and anxiety, and further improve adherence and viral load outcomes.[13]

Marital Status

Marital status can affect the social and psychological dynamics of patients undergoing ARV therapy, which ultimately impacts the level of adherence and treatment success. Recent studies have shown that married individuals often face psychological stress related to family roles and complex interpersonal dynamics, which can affect therapy management.[14] Married patients may also have difficulty disclosing their HIV status to their partners or family due to fears of stigma and discrimination, which can interfere with treatment consistency.[15,16] In addition, marital relationships can also be a source of emotional stress, especially when both partners are living with HIV. Seropositive couples face challenges such as shared anxiety and emotional exhaustion, which can affect adherence to therapy and increase the risk of unsuppressed viral load.[17] This is consistent with the findings of this study, which showed that patients with PLHIV partners had a higher risk of unsuppressed viral load (Adjusted PR: 1.27; $p = 0.004$).

In contrast, unmarried patients tend to have more control over their treatment schedule and decision-making, and experience less pressure from social responsibilities that can hinder engagement in health services.[18,19] Several studies have also found that unmarried individuals have higher levels of ARV adherence, which contributes to better therapy success compared to those who are married.[18] Although in this study the variable of marital status did not appear as an independent determinant factor in the multivariate model, it is likely influenced by mediating variables such as the partner's HIV status, clinical stage, and adherence to appointments. In other words, the effect of marital status on viral load suppression may work indirectly through other variables that are more dominant in the statistical model.[17 19]

Opportunistic Infection

Opportunistic infections (OIs) remain a major complication in people living with HIV/AIDS (PLHIV), especially in low- and middle-income countries. However, in this study, the presence of OIs did not emerge as a statistically significant predictor of viral load suppression in the multivariate model ($p > 0.05$). The results of the bivariate analysis showed a tendency that the more OIs a patient experienced, the higher the proportion of unsuppressed viral load. This is in line with previous findings

highlighting the clinical impact of OI on the decline in immune response and the success of ART therapy. A prospective study by Vo et al., in Vietnam on 121 patients with advanced HIV, showed that the number of OIs significantly increased the risk of in-hospital mortality, especially in patients with ≥3 infections (OR: 4.41; $p < 0.05$), this study reinforces the importance of early OI prevention and control, not only to prevent disease progression but also to reduce mortality. The results also showed that although the presence of OIs was not statistically significant in Vo et al.'s study, it still has a major clinical impact on patient health, especially if the number of infections is multiple or does not receive prophylaxis therapy.[20]

However, the insignificant relationship between OIs and viral load in this study can be explained by several factors, including Effective OIs Control and Management. The HIV program in Bekasi may have been successful in the early diagnosis and treatment of OIs so the presence of OIs did not have a significant impact on viral load suppression. This is in line with findings from Oladimeji et al. in Nigeria, which showed that program support through strengthening private health services, increasing DOTS officer training, and providing free treatment was able to increase TB treatment success by up to 78%. The study emphasized the importance of early care-seeking, diagnostic efficiency, and collaborative TB/HIV interventions in improving treatment outcomes and reducing failure rates.[21]

Another reason is that with the Early Initiation of ART, with the increasingly widespread implementation of the "test and treat" strategy, many patients had started ART before clinically significant OIs had developed. This was supported by a systematic review by Anglemyer et al., which analysed 24 studies (including 3 RCTs and 21 cohorts) to compare the clinical outcomes of HIV patients who started ART at CD4 levels ≥350 cells/mm³ versus those who delayed until CD4 <350 cells/mm³. The results of the meta-analysis showed that early ART initiation significantly reduced the risk of death (RR 0.66; 95% CI: 0.55–0.79) and progression to AIDS or death (RR 0.48; 95% CI: 0.26–0.91), as well as reducing the risk of serious non-AIDS infections (RR 0.14; 95% CI: 0.03–0.64). These findings support the strategy of early ART initiation as an effective approach to improve survival, reduce infectious complications, and accelerate viral load suppression.[22]

Finally, since the data used in this study came from the HIV AIDS Information System (HIV Information System), there was potential bias in the recording and classification of opportunistic infections. This bias could be due to limitations in medical documentation, mislabelling, or incomplete input from health workers. A study by Perets et al. identified that data bias due to missing information, incomplete recording, and poor labelling were among the six main sources of bias in electronic health records (EHRs). This bias contributes to erroneous clinical judgments and leads to inaccurate conclusions in secondary data-based studies. Furthermore, the study also explained that disparities in access to services, lack of training of officers in documentation, and administrative burdens were the main causes of poor labelling of sensitive medical information, such as OIs diagnoses. In this context, underreporting or misclassification of the type and severity of OIs could result in an underestimation of the effect of OIs on antiretroviral therapy outcomes, as may have occurred in this study.[23]

Clinical Stage

The advanced clinical stage at ART initiation was significantly associated with poorer viral suppression outcomes. Patients at clinical stages 3 or 4 had a 2.52-fold increased risk of unsuppressed viral load (Adjusted PR: 2.52; $p < 0.001$). This finding is consistent with previous studies showing that the more advanced the clinical stage, the greater the likelihood of ART failure. A study by Mesic et al. in Myanmar showed that the WHO clinical stage at ART initiation was a significant factor influencing the risk of virologic failure. Although bivariate analysis found that patients with WHO stage 2 had a 1.26-fold higher risk of virologic failure compared to stage 1 (HR = 1.26; 95% CI: 1.06–1.49), a trend of higher risk was also seen in stages 3 and 4.[24]

The association between advanced clinical stages and poor ART outcomes may be explained by delayed initiation of treatment, which often leads patients to a more severe phase of the disease before fully benefiting from ART. Tao et al. in a systematic review and meta-analysis of 29 global studies, found that 36.1% of HIV patients experienced delays in initiating ART, with the highest prevalence occurring in male patients and those with high CD4 counts, who tended to delay therapy because they felt “still healthy”.[25] Furthermore, delayed diagnosis also implies a lack of opportunities for adequate social and psychosocial support, which indirectly increases the risk of therapy failure. These results therefore reinforce the urgency to expand early detection programs and accelerate the “test and treat”

initiative as recommended by WHO, to prevent patients from entering an advanced stage before ART is initiated.[26]

Duration on ART

Duration of ART is one of the important factors that influence the success of viral load suppression in HIV patients. In this study, the majority of patients (76.3%) had undergone ART for 1–5 years. Although this variable was not statistically significant in the final multivariate model (p = 0.181), the bivariate analysis showed that patients with ART duration >5 years had a lower likelihood of experiencing unsuppressed viral load (Crude PR: 0.73; 95% CI: 0.45–1.17), compared to those who underwent ART for 1–5 years.

This finding is consistent with the results of a study by Dhinsa et al. (2025) in Addis Ababa, which showed that the duration of ART therapy plays a significant role in achieving viral load suppression. In the study, patients who had undergone ART for more than 12 months had a significantly higher chance of viral load suppression compared to those who underwent ART for ≤12 months. Specifically, patients with a duration of therapy of 13–35 months, 36–59 months, and ≥60 months each had a significantly increased chance of suppression (Adjusted HR 6.586; 6.826; and 6.596, respectively). This indicates that stability in long-term ART use can support the success of therapy, which is also strengthened by increased adherence and the possibility of improving immune conditions over time.[27]

WHO confirms that long-term use of ART enables suppression of HIV viral replication to undetectable levels, which is essential for immune system recovery and prevention of transmission. Over time, long-term therapy also helps reduce chronic inflammation caused by HIV and the risk of serious complications. With current simpler and better tolerated ART regimens, patients who remain on long-term treatment are more likely to maintain adherence, which is critical for achieving and maintaining viral load suppression.[28] Although in this study, the association was not statistically significant, the duration of therapy remains an important component to monitor in evaluating the effectiveness and long-term success of antiretroviral treatment in HIV/AIDS patients. Periodic evaluation of virologic response based on duration of therapy can provide insight into the long-term effectiveness of ART and identify the need for switching regimens or additional interventions.

ARV Regimen

The results of this study indicated that the type of ARV regimen had a significant effect on the level of viral load suppression in HIV/AIDS patients. The TLD regimen (Tenofovir, Lamivudine, Dolutegravir) is associated with a lower likelihood of achieving viral load suppression compared to TLE (Tenofovir, Lamivudine, Efavirenz) and other regimens (Adjusted PR: 0.52; p = 0.001). This finding is different from most global studies that show the superiority of TLD, but is not entirely without support. This finding appears to contrast with previous reports by WHO, Smith et al, Gupta et al., Wang et al., and Zhao et al. (which generally indicated that Dolutegravir-based regimens offer superior virologic suppression compared to Efavirenz-based regimens.[29-33] Several factors may potentially explain this discrepancy observed in the Bekasi District.

First, Most TLD patients were transition patients from TLE, as also shown by Majula and Mweya's study in Tanzania, which found that transition from TLE to TLD was accompanied by a small increase in virologic failure from 3.6% to 6.8%, and not all patients showed a decrease in viral load after transition. In that study, only 19.2% of patients experienced a decrease in viral load after switching to TLD, indicating that the effectiveness of TLD may be reduced if used in patients with a history of previous regimens, such as TLE.[34] These findings are in line with results reported in the study by Schramm et al. in Malawi, which evaluated a mass transition from a TLE-based NNRTI regimen to a TLD without prior viral load testing. Despite high overall viral load suppression rates (97.9% at month 12), some patients still experienced virologic failure, especially those with high viral loads before transition (Adjusted OR 14.1 to 64.4), and showed low plasma dolutegravir levels due to poor adherence. In addition, two patients developed dolutegravir resistance mutations (Arg263Lys and Gly118Arg) only six months after transition, indicating a risk of resistance when dolutegravir is given in an uncontrolled virological setting and against a background of NRTI resistance.[35] A similar situation may have occurred in this study, where patients previously on TLE were switched to a TLD without prior viral load or resistance testing, resulting in a suboptimal regimen being given. This has the potential to make

dolutegravir work functionally as a monotherapy due to the decreased effectiveness of the NRTI backbone, which could theoretically accelerate the emergence of resistance to dolutegravir itself.

Second, emerging resistance to Dolutegravir could develop within the local population, particularly among individuals with prior exposure to suboptimal ART regimens. Resistance mutations could diminish the effectiveness of Dolutegravir, leading to reduced virological suppression. Third, adherence behaviours might differ between regimens due to their side effect profiles. Patients may experience adverse effects differently, influencing their willingness and ability to consistently adhere to treatment, with TLE potentially being perceived as more tolerable in this context. Fourth, socioeconomic barriers may have played a role. Silva et al. emphasized that economic factors, such as limited financial resources and challenges in accessing healthcare services, can undermine the success of Dolutegravir-based therapy, especially in resource-limited settings like Bekasi.[36] Fifth, the results of this study indicate that most patients who successfully received ARV therapy were in the group using other regimens, which in this context refers to second-line therapy. This finding is in line with the study by Amstutz et al. in Lesotho, which showed that patients with low-level viremia (VL 100–999 copies/mL) who were switched to second-line ARV therapy had higher levels of viral suppression than those who remained on first line (55% vs. 25%; $p = 0.009$). The similarity of these findings supports that focusing on the second-line can be an effective strategy to improve therapy success, especially in patients who show a suboptimal virological response to the first-line. Thus, the use of other regimens in this study may reflect the right clinical policy in dealing with virologic failure, even though VL levels have not reached the threshold of >1,000 copies/mL according to WHO guidelines.[37]

Finally, programmatic issues such as inconsistent drug supply chains, disparities in healthcare provider training, and variability in patient counselling could affect the effective delivery and management of ART regimens. Variations in service quality could lead to suboptimal treatment outcomes regardless of the intrinsic potency of the regimen used. Considering these potential explanations, future studies focusing on evaluating local drug resistance profiles, treatment adherence patterns, and pharmacovigilance are essential. Such studies will help to optimize ART regimen recommendations and tailor HIV treatment strategies to the specific needs and conditions of the Bekasi population.

Although WHO officially recommends TLD as a first-line regimen due to its high viral load suppression potential, good tolerability, and low resistance to dolutegravir, studies have shown that optimal efficacy can only be achieved when the transition to TLD is accompanied by close monitoring of adherence, enhanced counselling, and resistance testing when possible.[26] Thus, the results of this study emphasize the need for an individualized approach to the use of ARV regimens, including consideration of adherence factors, history of previous regimen use, and related laboratory tests before making a broad switch to TLD at the population level.

Body Mass Index

In this study, most patients who experienced viral load suppression (≤50 copies/mL) had normal to overweight nutritional status. As many as 44.4% of patients were classified as overweight or obese, while 42.5% were in the normal category, and only 13.1% were classified as underweight. Although statistically insignificant ($p = 0.187$), overweight patients showed a greater tendency to achieve viral load suppression compared to the underweight group. This finding is in line with the results of the study by Crum-Cianflone et al., which showed that weight status, both underweight and obese, affects immune recovery during ARV therapy. In the study, HIV patients who were in the underweight and obese categories experienced a smaller increase in CD4 count and CD4/CD8 ratio compared to patients with normal BMI during treatment in the HAART era. This suggests that both deficits and excess weight can have a negative impact on long-term immune responses. Obesity is associated with a chronic inflammatory state that can inhibit T cell regeneration, while underweight reflects poor nutritional status that also inhibits immune system repair. Thus, maintaining nutritional status within the normal range is important in supporting the success of ARV therapy.[38]

Research by Madec et al. in Africa showed that patients with higher BMI tended to maintain lower viral loads, especially those with good nutritional status when starting therapy. This suggests that optimal nutritional status may support therapeutic response by improving immune function and drug metabolism.[39] However, overweight and obesity status is not completely protective. A study by Koethe et al. warned that extreme obesity can alter ARV pharmacokinetics, including fat distribution and drug

metabolism, which can negatively impact virological success if not properly monitored.[40] Thus, regular BMI monitoring is important as part of the clinical evaluation of HIV patients. Underweight patients need special attention because they are at risk of therapy failure, while overweight patients still need monitoring so as not to enter the extreme obesity category, which can interfere with the effectiveness of treatment.

Comorbid

In this study, most HIV/AIDS patients in Bekasi Regency did not have comorbidities (96.4%), and only 3.6% were recorded as having comorbidities. Although comorbidities were not statistically significant variables in the multivariate model, the presence of comorbidities remains an important clinical factor that needs to be considered in the success of ARV therapy. Previous studies have shown that comorbidities such as diabetes, hypertension, and others can affect the success of viral load suppression. Comorbidities can aggravate the patient's immunological burden and reduce the effectiveness of ARV therapy, either through chronic inflammation or drug interactions that interfere with ARV metabolism. A study by Hasse et al. in Europe showed that HIV patients with ≥2 comorbidities had a higher risk of virologic failure than those without comorbidities. Comorbidities also increase the risk of hospitalization and mortality in HIV patients.[41]

In addition, a study by Obirikorang et al. in Ghana found that HIV patients with tuberculosis comorbidities were more likely to experience high viral loads (>1,000 copies/mL), which is associated with increased risk of transmission and drug resistance. This comorbidity exacerbates immunodepression and slows CD4 count recovery after ARV therapy.[42] Furthermore, comorbidities such as metabolic disorders (e.g., dyslipidaemia and insulin resistance) which are common in HIV patients on long-term therapy, may affect the effectiveness of ARVs through altered pharmacokinetics, reduced blood drug concentrations, and increased risk of virological failure.[38]

Although the proportion of patients with comorbidities in this study was small, this could reflect two possibilities: first, the effectiveness of the comorbidity control program in Bekasi, which is quite good; or second, limitations in medical recording in the HIV information system used. Therefore, it is important to improve early detection and recording of comorbidities, as well as the integration of HIV treatment services with chronic disease management.

Partner's HIV Status

In this study, the partner's HIV status was shown to be a significant determinant of the success of ARV therapy based on viral load levels. Patients having partners of HIV-positive people (PLHIV) have a higher risk of experiencing unsuppressed viral load compared to patients whose partners do not have HIV or whose status is unknown. Multivariate analysis showed that patients with PLHIV partners had a 1.27 times greater risk of experiencing unsuppressed viral load (Adjusted PR: 1.27; 95% CI: 1.08–1.49; p = 0.004). These results can be explained as related to the emotional and psychosocial burden experienced by seropositive partners. A study by Nhamo et al. in Zimbabwe showed that seropositive partners often experience shared emotional distress, anxiety about the future, and treatment fatigue that impact therapy consistency and virological success. Limited social support and double stigma also exacerbate this situation and have the potential to reduce adherence to treatment.[17]

In contrast, patients with HIV-negative or unknown partners tend to show higher levels of viral load suppression. This may be due to a stronger motivation to protect their partners from HIV transmission, which increases adherence to treatment. Similar findings were also found in a study by Adebayo et al. in Nigeria, which showed that disclosure of HIV status to partners and emotional support increased the success of ARV therapy.[16] In addition, a partner's HIV status can influence care behaviour, communication about treatment, and decision-making dynamics in the household. Sero discordant partners tend to be more aware of the risk of transmission, so they are more active in supporting therapy schedules and clinic visits, as shown in a systematic review by Abdullah et al. in Sub-Saharan Africa.[18] Thus, a partner's HIV status is a factor that not only influences clinically but also socio-psychologically the success of HIV therapy. Couple-based interventions, including co-counselling and strategies to increase emotional support in seropositive relationships, can be an effective approach to improve adherence and reduce viral load levels.

CONCLUSION

This study demonstrated that ART success among HIV/AIDS patients in Bekasi Regency was significantly influenced by adherence to appointments, clinical stage at treatment initiation, ARV regimen type, and partner's HIV status. High appointment and treatment adherence are critical for viral load suppression, underscoring the need for continuous adherence support interventions. Early clinical staging highlights the necessity of widespread HIV testing and prompt treatment initiation. The observed better outcomes among patients on TLE regimens compared to TLD regimens suggest that local resistance patterns, adherence behavior, socioeconomic factors, and healthcare system challenges affect regimen effectiveness, emphasizing the importance of individualized treatment guided by viral load and resistance monitoring. Partner HIV status also impacts treatment success, reinforcing the role of psychosocial and partner support integration into care frameworks. These findings advocate for multifaceted, patient-centered interventions combining clinical management and social support mechanisms. Strengthening differentiated service delivery, enhancing community support, optimizing regimen selection, and integrating mental health services are essential to improve treatment outcomes. Achieving Indonesia's 95-95-95 targets and the global ambition to end AIDS by 2030 demands sustained, targeted efforts tailored to the needs of HIV/AIDS populations in diverse, resource-limited settings such as Bekasi Regency. Future research should explore longitudinal causal relationships, local drug resistance trends, and psychosocial determinants to further refine ART success strategies.

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