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# Association Between Duration of Antiretroviral Therapy and Virological Suppression Among HIV Patients in South Sulawesi, Indonesia

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**ABSTRACT**

HIV infection remains a major global health problem requiring lifelong therapy to suppress viral replication. Antiretroviral therapy (ART) has been proven effective in reducing viral load; however, its success may vary depending on treatment duration and patient adherence. This study aimed to analyze the relationship between ART duration and virological status among HIV patients receiving first-line ART in South Sulawesi, Indonesia. This descriptive cross-sectional study used medical record data from patients who underwent viral load testing at the referral laboratory in South Sulawesi. A total of 221 patients who had received ART for at least six months were included. The main variables were ART duration (in months) and virological status, categorized as successful (≤1000 copies/mL) or failed (>1000 copies/mL). Data were analyzed descriptively using frequency and percentage distributions. Most patients in all treatment duration groups achieved virological suppression, with success rates ranging from 90% to 100%. Virological failure was observed in 3.6% of patients, particularly in those with treatment durations of 144–166 months. Overall, 96.4% of patients achieved successful virological suppression, meeting the national target, This study demonstrates high rates of virological suppression among HIV patients in South Sulawesi, supporting the effectiveness of first-line ART programs in the region. Routine viral load monitoring and continuous adherence support are essential to sustain long-term treatment success. Future research should include immunological and adherence parameters to provide a more comprehensive evaluation of treatment outcomes.
**Keywords :** HIV; antiretroviral therapy; treatment duration; virological status; viral load

## INTRODUCTION

Human Immunodeficiency Virus (HIV) remains one of the major global health problems and continues to be a significant disease burden. Antiretroviral therapy (ART) has revolutionized the course of HIV infection by suppressing viral replication, reducing morbidity, and prolonging patient survival [1,2]. The long-term effectiveness of ART is largely determined by patient adherence and treatment duration, making routine monitoring essential to ensure treatment success [3].

Virological status, measured through viral load testing, is the primary indicator of ART success. A viral load of <1000 copies/mL is defined as treatment success according to WHO guidelines and Indonesian Ministry of Health Regulation No. 87 of 2014 [4,5]. Sustained virological suppression not only reduces the risk of HIV transmission but also indicates effective treatment response [6,7]. Previous cohort studies have confirmed that maintaining virological suppression is a key indicator of long-term ART success [8,9].

The duration of ART is closely related to virological status and treatment outcomes. Patients with longer treatment duration tend to have a higher likelihood of achieving undetectable viral load, although variations in immune response may still occur [10,11]. Research in Indonesia has reported that adherence, ART regimen, and treatment duration are critical factors in achieving virological suppression [12,13]. On the other hand, some studies have found that certain patients continue to experience delayed immune recovery despite controlled viral load, indicating the complexity of the relationship between virological suppression and immune response [14,15].

While national virological suppression rates are reported, subnational data from Eastern Indonesia—particularly South Sulawesi—are scarce, limiting targeted program evaluation. In Indonesia, particularly in South Sulawesi, data on the relationship between treatment duration, virological status, and immune response remain limited. Therefore, this study aims to analyze the association between the duration of antiretroviral therapy and virological suppression among HIV patients in South Sulawesi, Indonesia.

## MATERIALS AND METHODS

This study was a descriptive cross-sectional study conducted among HIV patients receiving first-line antiretroviral therapy (ART) in South Sulawesi Province. The study population consisted of all HIV patients who underwent viral load testing within the province. The research sample was obtained from medical records of patients who met the inclusion criteria, namely having received ART for at least six months and possessing complete viral load data. A total of 221 patients fulfilled the inclusion criteria and were included in the analysis.

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The study variables included patient characteristics (sex, age, and population group), duration of ART, and virological status based on viral load test results. ART duration was calculated from the date of therapy initiation to the date of viral load testing and categorized into ≤12 months, 13–36 months, and >36 months, based on programmatic monitoring intervals recommended by the Indonesian HIV treatment guidelines.

Data were collected through document review of laboratory medical records. Data extraction and entry were performed using a standardized form, and data completeness was verified through double-checking to ensure accuracy. Data were analyzed descriptively to present frequency and percentage distributions. Cross-tabulation and chi-square tests were used to assess the association between ART duration and virological suppression. This study obtained ethical approval from the Ethics Committee of Poltekkes Kemenkes Makassar (Approval No.: 1524/M/KEPK-PTKMS/VIII/2025.

## RESULTS

A total of 221 HIV patients undergoing first-line antiretroviral therapy (ART) in South Sulawesi during the study period were recorded in the viral load register and met the inclusion criteria. The characteristics of the study subjects are presented in Table 1. Based on sex, the majority of patients were male, with 163 individuals (73.8%), while female patients accounted for 58 individuals (26.2%). In terms of age groups, most patients were in the productive age range, namely 21–30 years (21.7%), 31–40 years (34.8%), and 41–50 years (29.9%), whereas only a small proportion of patients were found in the age groups below 20 years and above 50 years. Regarding population groups, the largest distribution was among men who have sex with men (MSM), comprising 107 patients (48.4%), followed by the general population with 63 patients (28.5%). Meanwhile, the smallest proportions were found among MSM with tuberculosis, clients of sex workers, and female sex workers. Based on treatment duration, most patients had been on ART for 6–28 months (53%), followed by 29–51 months and 52–74 months (42%), while only a small number of cases were found with treatment duration exceeding 170 months.

Table 1. Characteristics of HIV Patients Undergoing First-Line ART in South Sulawesi, Indonesia

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| **Sex** | | |
| Male | 163 | 73,8 |
| Female | 58 | 26,2 |
| **Age (years)** | | |
| 11-20 | 6 | 2,7 |
| 21-30 | 48 | 21,7 |
| 31-40 | 77 | 34,8 |
| 41-50 | 66 | 29,9 |
| 51-60 | 18 | 8,1 |
| 61-70 | 5 | 2,3 |
| 71-80 | 1 | 0,5 |
| **Population Group** | | |
| Anak ODHIV | 3 | 1,4 |
| LSL | 107 | 48,4 |
| LSL, Penyakit TB | 1 | 0,5 |
| Pasangan ODHIV | 11 | 5,0 |
| Pasangan Risti | 2 | 0,9 |
| Pelanggan PS | 1 | 0,5 |
| Penasun | 14 | 6,3 |
| Penyakit TB | 15 | 6,8 |
| Populasi Umum | 63 | 28,5 |
| Waria | 3 | 1,4 |
| WPS | 1 | 0,5 |
| **Treatment Duration (Months)** | | |
| 6–28 | 53 | 24 |
| 29–51 | 42 | 19 |
| 52–74 | 42 | 19 |
| 75–97 | 32 | 14,5 |
| 98–120 | 18 | 8,1 |


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| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| 121–143 | 17 | 7,7 |
| 144–166 | 10 | 4,5 |
| 167–189 | 5 | 2,3 |
| 190–212 | 2 | 0,9 |
| **Viral Load (Copies/mL)** | | |
| Undetectable | 165 | 74,7 |
| ≤1000 | 48 | 21,7 |
| >1000 | 8 | 3,6 |

Remarks: ODHIV-orang dengan HIV; LSL-lelaki seks dengan lelaki; TB-tuberkulosis; Risti- risiko tinggi; PS-pekerja seks; Penasun-pengguna narkoba suntik; WPS-wanita pekerja seks

The analysis of the relationship between ART duration and virological status showed that the majority of patients in all treatment duration groups achieved virological success (VL ≤1000 copies/mL). The success rate was 96.2% in the 6–28 months group, 95.2% in the 29–51 months group, 97.6% in the 52–74 months group, and 93.8% in the 75–97 months group. In the 98–120 months and 121–143 months groups, all patients achieved complete virological suppression (100%). The 144–166 months group showed the lowest success rate (90%) and the highest failure rate (10%) among all groups, while in the 167–189 months and 190–212 months groups, all patients again achieved 100% success. Overall, out of 221 patients, 213 (96.4%) achieved virological suppression (VL ≤1000 copies/mL), while only 8 (3.6%) experienced virological failure (VL >1000 copies/mL). A chi-square test indicated no statistically significant difference ($p > 0.05$) in virological failure rates across ART duration groups, suggesting that treatment duration alone may not determine virological outcomes in this cohort. A summary of virological success rates by ART duration is illustrated in Table 2 and Figure 1**,** showing consistently high suppression across all groups, with a slight dip observed in the 144–166 months group.

Table 2. Distribution of Virological Status Based on ART Duration

| ART Duration (months) | Success | | Failure | %Success | %Failure |
|---|---|---|---|---|---|
| | Undetectable | (VL ≤1000) | (VL >1000) | | |
| 6–28 | 30 | 21 | 2 | 96,2 | 3,8 |
| 29–51 | 30 | 10 | 2 | 95,2 | 4,8 |
| 52–74 | 34 | 7 | 1 | 97,6 | 2,4 |
| 75–97 | 27 | 3 | 2 | 93,8 | 6,3 |
| 98–120 | 15 | 3 | 0 | 100,0 | 0,0 |
| 121–143 | 14 | 3 | 0 | 100,0 | 0,0 |
| 144–166 | 9 | 0 | 1 | 90,0 | 10,0 |
| 167–189 | 5 | 0 | 0 | 100,0 | 0,0 |
| 190–212 | 1 | 1 | 0 | 100,0 | 0,0 |
| **Total** | 165 | 48 | 8 | 96,4% | 3,6% |

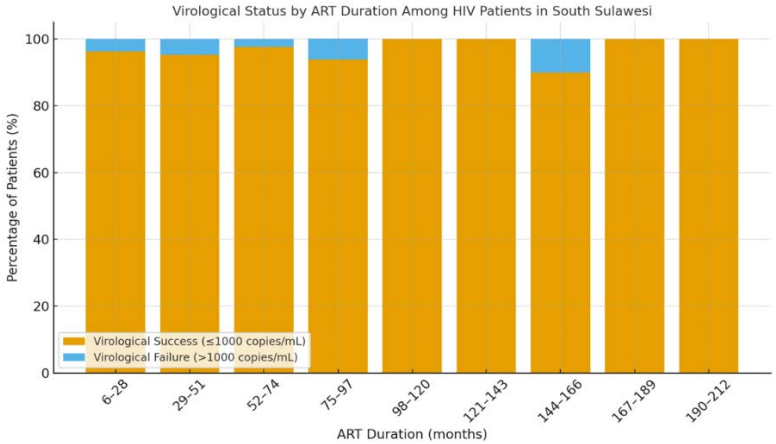


Figure 1. Distribution of virological suppression rates according to ART duration among HIV patients in South Sulawesi.


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**DISCUSSION**

The results of this study show that most patients achieved virological suppression at various durations of ART. This finding aligns with global evidence indicating that long-term antiretroviral therapy is capable of consistently suppressing viral replication and substantially lowering the risk of HIV disease progression over time [16,17]. Sustained virological suppression has long been regarded as the most important benchmark of ART success, representing stable therapeutic efficacy, good medication adherence, and optimal patient engagement in care [18]. In addition, maintaining low or undetectable viral load levels has been associated not only with improved clinical outcomes but also with reduced HIV transmission at the population level, thereby contributing to broader public health goals. These outcomes reinforce the importance of ensuring continuous access to ART and enhancing the quality of HIV care services, especially in regions where gaps in treatment continuity remain a challenge.

In addition, extended ART duration allows sufficient time for patients to achieve both clinical and immunological stabilization. Over prolonged therapy, immune reconstitution—particularly the gradual increase in CD4 cell counts—provides long-term protection against opportunistic infections and improves overall survival. However, the pace and degree of immune recovery often differ widely across individuals. Patients initiating ART at an advanced disease stage or with extremely low CD4 counts frequently experience delayed or incomplete immune restoration, even when achieving viral suppression. This heterogeneity highlights the multifactorial nature of treatment outcomes, suggesting that early diagnosis, timely ART initiation, and ongoing clinical monitoring are crucial components for achieving full immunological benefits. As a result, strengthening HIV testing strategies and expanding early treatment initiation programs remain essential to maximize treatment effectiveness.

Several studies in Asia have reported that patients undergoing therapy for more than 24 months tend to achieve higher rates of virological suppression compared to those newly initiated on ART, although variations may occur due to factors such as adherence, regimen type, and comorbidities [19,20]. In Indonesia, previous studies have also shown that treatment duration is significantly associated with virological suppression, yet a small proportion of patients still experience treatment failure, primarily due to non-adherence or emerging drug resistance [21,22]. These findings are consistent with studies from Africa, which reported that despite the overall effectiveness of ART, approximately 5–10% of patients continue to experience virological failure after long-term therapy [23]. Such observed failure highlights persistent gaps in retention in care, timely regimen switching, and access to resistance testing. Consequently, ongoing refinement of treatment algorithms and reinforcement of adherence strategies are essential to achieving optimal long-term virological outcomes.

Beyond clinical factors, social and psychological determinants also play a crucial role in shaping long-term treatment outcomes. Evidence shows that strong family support, reduced stigma, and easy access to healthcare services meaningfully contribute to improved adherence among people living with HIV. Conversely, individuals experiencing stigma, discrimination, mental health challenges, or limited social support often struggle to maintain consistent medication-taking behaviors, thereby increasing their risk of virological rebound and treatment failure. Structural barriers—such as long travel distances, financial constraints, and limited clinic hours—can further hinder regular treatment access, particularly in rural or geographically remote settings. These challenges underscore the need for integrative, community-based interventions that focus on counseling, mental health support, peer networks, and stigma reduction programs to ensure that patients can adhere to ART over the long term [24].

The differences observed across ART duration groups in this study suggest that while longer treatment is generally associated with higher suppression rates, sustained success still depends on continuous adherence and effective program monitoring. The small proportion of virological failure observed, particularly in patients with longer treatment durations, may indicate potential challenges such as medication fatigue, irregular follow-up visits, or the gradual emergence of resistance mutations. Long-term ART may also lead to declining motivation or complacency among patients who feel clinically stable, making them less likely to attend appointments or refill their medications on time. This emphasizes the importance of maintaining regular health education initiatives, adherence reinforcement strategies, and close clinical supervision to promptly identify early signs of treatment disengagement [25].

Another contributing factor is the variability of ART regimens used across patients, particularly for those with comorbidities or previous treatment history. For example, individuals with coexisting conditions such as tuberculosis, hepatitis, or metabolic disorders often require regimen modifications, which may influence the rate and consistency of virological suppression. Furthermore, drug–drug interactions, cumulative side effects, and tolerability issues can reduce adherence over time, contributing to treatment fatigue. Patients transitioning from older regimens to newer options may also experience challenges, particularly if they lack clear guidance or experience anxiety regarding regimen changes. Therefore, careful regimen selection, regular monitoring of drug toxicity, individualized patient counseling, and timely therapeutic adjustments play a pivotal role in optimizing the long-term success of ART programs [26].

Furthermore, the introduction of dolutegravir-based regimens has been shown to accelerate viral suppression and


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improve patient outcomes (27). Dolutegravir offers several advantages, including high genetic barrier to resistance, better tolerability, and more rapid reduction in viral load levels compared to earlier regimens. However, other studies emphasize that long-term therapy does not guarantee success without consistent adherence and proper monitoring (28). Even with potent regimens, gaps in viral load testing, delayed detection of treatment failure, and suboptimal adherence can hinder long-term outcomes. These insights underscore the importance of scaling up viral load monitoring capacity, strengthening routine clinical visits, and expanding differentiated service delivery models to ensure that patients receive timely and tailored support based on their individual needs.

In the context of South Sulawesi and other parts of Eastern Indonesia, where access to routine viral load testing and adherence counseling may still be limited, strengthening these systems is crucial. Geographic barriers, uneven distribution of laboratory infrastructure, and workforce limitations continue to impede timely diagnosis of treatment failure and hinder comprehensive patient management. To address these challenges, health programs should prioritize investments in laboratory capacity, supply chain stability, transportation systems for sample referral, and digital health solutions that support follow-up and appointment reminders. Additionally, reinforcing patient education on adherence, encouraging community engagement, and integrating support from local health workers can help sustain virological suppression and prevent the emergence of drug-resistant HIV strains.

## CONCLUSION AND RECOMMENDATIONS

This study demonstrates high rates of virological suppression among HIV patients in South Sulawesi, with 96.4% achieving successful viral load reduction. The consistently high suppression rates across various ART duration groups indicate the effectiveness of first-line ART programs in the region. However, minor variations in failure rates highlight the need for continuous monitoring and adherence support, particularly among patients on long-term therapy.

To sustain these outcomes, routine viral load monitoring should be fully integrated into primary healthcare services across South Sulawesi to enable early detection of treatment failure and timely intervention. Future studies are recommended to include immunological parameters such as CD4 counts and adherence assessments to provide a more comprehensive understanding of treatment outcomes and program performance.

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