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Multicenter study in Turkiye of unsuppressed viremia in people living with human immunodeficiency virus: aegean experience

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Abstract

Introduction/Objective This Turkish study aimed to investigate the factors that contribute to the failure of virological suppression in people with human immunodeficiency virus (HIV) receiving antiretroviral therapy (ART). The factors evaluated were sociodemographic characteristics, opportunistic infections, polypharmacy, comorbidities, and the ART regimen used. The purpose of this investigation was to obtain important insights that can be utilized to improve treatment strategies at both individual and public health levels.

Methods This multicenter retrospective case-control study compared data from 263 patients with suppressed viremia with 125 with unsuppressed viremia, all treated at one of three hospitals in the Aegean region of Turkiye. Sociodemographic and clinical characteristics and ART regimen details were compared between the two groups. Logistic regression analysis was used to identify the predictors of virological failure.

Results Patients with unsuppressed viremia were significantly more likely to be older, have lower educational levels, and reside in large cities. Our logistic regression analysis showed that each additional month since HIV diagnosis increased the risk of virological failure by 2%. Moreover, each 1% increase in nadir CD4 + T-cells reduced the risk of virological failure by 4%. Opportunistic infections increased the risk of virological failure by 3.25 times. Interestingly, virological failure was 6.5 times more likely in patients who did not suffer ART side effects.

Conclusions This study identified the sociodemographic, clinical, and treatment-related factors that contribute to virological failure in people with HIV in Turkiye. This can be utilized to develop individualized treatment strategies and improve virological control and clinical outcomes.

Keywords Antiretroviral therapy, Human immunodeficiency virus, Turkiye, Unsuppressed viremia

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Introduction

HIV (human immunodeficiency virus) affects millions of people worldwide and can be fatal if left untreated. With the advent of antiretroviral therapy (ART), the life expectancy of people living with HIV (PLWH) has significantly increased [1, 2]. ART is the fundamental strategy in the control of HIV infections and the improvement of patients' quality of life. Today, viral suppression is typically achieved within the first six months of treatment, particularly with antiretroviral regimens that have high resistance barriers. However, in some patient populations, virological suppression is not achieved, even after more than 6 months of individualized ART. Studies have identified several factors associated with unsuppressed viremia, including age, gender, marital status, type of ART, poor adherence to ART, sociodemographic and psychological factors, poor absorption of antiretroviral drugs, coinfections, comorbidities, and substance use [3, 4]. Failure to achieve viral suppression is associated with both accelerated progression to acquired immunodeficiency syndrome (AIDS) and poor clinical outcomes. It also poses a significant public health risk [5, 6].

In Turkiye, HIV infection rates have been rising in recent years. According to 2024 data from the Ministry of Health, the number of reported HIV cases in the country currently exceeds 40,000 [7]. This increase, particularly when considering the exponential effects of transmission and the development of drug resistance, underscores the critical importance of treatment adherence and viral suppression [8, 9]. Although there have been some studies on unsuppressed viremia in the global literature, no such research has been conducted in Turkiye.

This study aims to investigate the factors contributing to virological failure in PLWH in Turkiye who are receiving ART. We evaluate various possible risk factors, including sociodemographic characteristics, opportunistic infections, polypharmacy, comorbidities, and ART characteristics. The findings obtained will have important implications at both the individual and public health levels, influencing HIV epidemiology and treatment practices in our region of Turkiye. They may also contribute valuable insights to national and international data.

Materials and methods

Participants and data collection

This was a multicenter retrospective case-control study. Data were collected from three centers in different major cities in the Aegean region. This was obtained from the electronic medical records of PLWH followed up at the Infectious Diseases and Clinical Microbiology Clinics of Balikesir Atatürk City Hospital, Mugla Sitki Kocman University Faculty of Medicine, and the Health Sciences University Izmir Tepecik Education and Research Hospital. The inclusion criteria for the case group were confirmed HIV diagnosis, receiving ART for a minimum of six months, being over 18 years of age, and meeting the definition for unsuppressed viremia at any point during follow-up. The control group criteria were a confirmed HIV diagnosis, being over 18 years of age, who had received ART for at least six months and never having met the definition of unsuppressed viremia during ART follow-up. For individuals with unsuppressed viremia who met the definition at different times during follow-up, the variables from the time of the first unsuppressed viremia episode were used in the analysis. Data from the five-year period preceding January 1, 2024 (i.e., between January 1, 2019 and December 31, 2023) were retrospectively collected from electronic medical records. The data collection process was conducted between June 15, 2024 and September 15, 2024.

Selection of study participants

This case-control study investigated unsuppressed viremia in PLWH. All participants had a diagnosis of HIV. The case group consisted of 125 individuals with unsuppressed viremia, while the control group consisted of 263 individuals with suppressed viremia. The total number of PLWH followed in each city was 995, 340, and 68, respectively. The number of cases in each city was 99, 26, and 3, respectively. The required sample size was calculated using data from a meta-analysis that reported the prevalence of unsuppressed HIV viremia as 8.1% [10]. The confidence interval was set at 95%, the margin of error at 5%, and the power at 80%. Using the Cochran formula, we found that the minimum sample size required for each city was approximately 114. Given the total number of PLWH in each city, stratified sampling was used. The required number of cases per city was calculated as 89 for Izmir, 30 for Mugla, and six for Balikesir. However, during the data collection process, only 26 cases were identified in Mugla, and three in Balikesir. Therefore, due to insufficient statistical power at the city level, no subgroup analyses were performed.

Study definitions and variables

Failure to suppress HIV-RNA < 50 copies/mL within six months in patients receiving ART is defined as unsuppressed viremia. We used national and international guidelines to define treatment success and failure more specifically [11, 12]. Virological suppression was defined as HIV ribonucleic acid (RNA) levels below the detection limit (< 50 copies/mL), virological nonresponse as failure to reduce viral replication below 200 copies/mL or maintain this level, incomplete virological response as HIV RNA levels above 200 copies/mL after 24 weeks of ART despite a significant decrease from baseline, virological rebound as a plasma HIV RNA level > 200 copies/mL after first achieving complete virological response, a viral

blip as a temporary positive HIV RNA level (≥ 50 copies/mL) after suppression that subsequently returns to negative (< 50 copies/mL), and low-level viremia as detectable but low HIV RNA levels (50–200 copies/mL) in two or more measurements. The test used to measure HIV-RNA was conducted using quantitative real-time PCR.

As all patients initiated ART within one week of HIV diagnosis and no patient was followed without treatment, the follow-up duration after ART initiation and the time since HIV diagnosis are equivalent in this study. The current viremia status of each participant was determined using their HIV RNA level at their most recent outpatient visit. A history of foreign travel was defined as having traveled abroad at least once within the year preceding the diagnosis of unsuppressed viremia. HIV clinical staging was based on the CD4 + T lymphocyte count and percentage detected at each patient's first visit and their clinical presentation at that visit, according to World Health Organization guideline [13]. Polypharmacy was defined as the concurrent use of five or more medications [14]. To determine the presence of ART side effects, patient feedback, physical examinations, laboratory tests, and imaging methods were used, and the Common Terminology Criteria for Adverse Events (CTCAE), v. 5.0 was employed. Effects were classified as present in those with CTCAE grade 2 or higher [15, 16].

Table 1 Demographic and clinical characteristics of participants

Variable	*n* (%)
City of follow-up center	
Izmir	288 (74.2)
Balikesir	26 (6.7)
Mugla	74 (19.1)
Sex	
Male	340 (87.6)
Female	48 (12.4)
Age group	
19–34	147 (37.9)
35–49	149 (38.4)
50–64	73 (18.8)
≥65	19 (4.9)
Education level	
Middle school or lower	146 (37.6)
High school	128 (33.0)
Higher education or above	114 (29.4)
Sexual orientation	
Heterosexual	228 (58.8)
LGBTQ+	160 (41.2)
Relationship status	
Married	134 (34.5)
Single/divorced	254 (65.5)
Smoking	
Current smoker	224 (57.7)
Nonsmoker/former smoker	164 (42.3)
Alcohol use	
Yes	195 (50.3)
No	193 (49.7)
Substance use	
Yes/occasionally	43 (11.1)
No	345 (88.9)
Presence of comorbidities	198 (51.0)
Presence of opportunistic infections*	36 (9.3)
Polypharmacy	21 (5.4)
Total	388 (100)

*Any time during the follow-up period

LGBTQ+, lesbian, gay, bisexual, transgender, queer/questioning, and more

Data analysis

The patient data collected in the study were analyzed using SPSS for MacOS, v.29.0 (IBM Corp., Armonk, NY, USA). Frequency and percentage were used to describe categorical variables, while median (interquartile range; Q1-Q3) was used for continuous variables. Comparisons between groups were made using the Mann–Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables. Logistic regression analysis was used to identify the predictors of low-level viremia. Results were considered statistically significant when the p-value was < 0.05.

Results

The study cohort comprised 388 patients, predominantly male (87.6%), with the majority aged between 19 and 49 years (76.3%). Most patients were followed up in Izmir (74.2%). Educational levels were relatively low, with 66.9% having a high school education or lower. A total of 58.8% identified as heterosexual, while 34.5% were married. Smoking levels were high, with 224 (57.7%) current smokers, and 50.3% consumed alcohol. Clinically, 51.0% had comorbidities, 9.3% had opportunistic infections, and 5.4% were experiencing polypharmacy (Table 1). Among the 388 patients, 67.8% had never experienced uncontrolled HIV viremia, while 32.2% had varying virological issues, including virological rebound (9.3%) and virological blips (8.0%). At diagnosis, 39.2% were at stage 2, followed by 35.1% at stage 1.

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Our chi-square analysis revealed several significant associations between patient characteristics and the occurrence of uncontrolled viremia. Patients from Izmir had a notably higher prevalence of uncontrolled viremia ($p = 0.034$), as did those over 40 ($p = 0.002$). Lower education levels were also linked to higher rates of uncontrolled viremia ($p = 0.002$), and the presence of opportunistic infections strongly increased the likelihood of uncontrolled viremia ($p = 0.001$) (Table 3).

Patients diagnosed at stage 3 had a significantly higher prevalence of uncontrolled viremia than those diagnosed at earlier stages ($p = 0.029$). Additionally, those

Table 2 The HIV diagnostic stages and treatment regimens of our cohort

Variable	*n* (%)
Uncontrolled HIV viremia	
Never experienced	263 (67.8)
Virological failure	15 (3.9)
Virological rebound	36 (9.3)
Incomplete virological response	24 (6.2)
Low-level viremia	19 (4.9)
Virological blip	31 (8.0)
Clinical stage of diagnosis	
Stage 1	136 (35.1)
Stage 2	152 (39.2)
Stage 3	100 (25.8)
Initial ART regimen	
Integrase-based	355 (91.5)
Nonintegrase-based	33 (8.5)
Multi-tablet	237 (61.1)
Single-tablet	151 (38.9)
Current ART regimen	
Integrase-based	384 (99.1)
Nonintegrase-based	4 (1.0)
Multi-tablet	226 (58.2)
Single-tablet	162 (41.8)
ART side effects	
Yes	19 (4.9)
No	369 (95.1)
Variable	**Median (IQR, Q1–Q3)**
Duration since HIV diagnosis (months)	30.5 (53, 13.0–66.0)
Baseline HIV RNA count at diagnosis (copies/mL)	129828.0 (486599.5, 28250.0–514849.5)
Baseline CD4 + T-cell count (cells/μL)	358.5 (360.5, 206.8–567.2)
Baseline CD4 + T-cell percentage	21.0 (15.3, 13.7–29.0)
Nadir CD4 + T-cell count (cells/μL)	325.5 (324.5, 175.8–500.2)
Nadir CD4 + T-cell percentage	20.0 (15.1, 11.8–27.0)

ART, antiretroviral therapy; HIV, human immunodeficiency virus; IQR, Interquartile Range

Table 3 Associations between patient characteristics and uncontrolled HIV viremia

	Uncontrolled viremia		Total	*p*
	Yes *n* (%)	No *n* (%)		
City of follow-up center				
Izmir	99 (79.2)	189 (71.9)	288	**0.034**
Balikesir	3 (2.4)	23 (8.7)	26	
Mugla	23 (18.4)	51 (19.4)	74	
Sex				
Male	112 (89.6)	228 (86.7)	340	0.416
Female	13 (10.4)	35 (13.3)	48	
Age group				
≤40	56 (44.8)	161 (61.2)	217	**0.002**
>40	69 (55.2)	102 (38.8)	171	
Education level				
Middle school or lower	63 (50.4)	83 (31.6)	146	**0.002**
High school	34 (27.2)	94 (35.7)	128	
Higher education or above	28 (22.4)	86 (32.7)	114	
Sexual orientation				
Heterosexual	79 (63.2)	149 (56.7)	228	0.221
LGBTQ+	46 (36.8)	114 (43.3)	160	
Relationship status				
Married	44 (35.2)	90 (34.2)	134	0.850
Single/divorced	81 (64.8)	173 (65.8)	254	
Smoking				
Current smoker	63 (50.4)	161 (61.2)	224	**0.044**
Nonsmoker/former smoker	62 (49.6)	102 (38.8)	164	
Alcohol use				
Yes	62 (49.6)	133 (50.6)	195	0.858
No	63 (50.4)	130 (49.4)	193	
Substance use				
Yes/occasionally	14 (11.2)	29 (11.0)	43	0.959
No	111 (88.8)	234 (89.0)	345	
Presence of comorbidities				
Yes	64 (51.2)	134 (51.0)	198	0.963
No	61 (48.8)	129 (49.0)	190	
Presence of opportunistic infections*				
Yes	23 (18.4)	13 (4.9)	36	**0.001**
No	102 (81.6)	250 (95.1)	352	
Polypharmacy				
Yes	10 (8.0)	11 (4.2)	21	0.120
No	115 (92.0)	252 (95.8)	367	

Significant *p*-values are shown in bold. *Any time during the follow-up period

HIV, human immunodeficiency virus, LGBTQ+, lesbian, gay, bisexual, transgender, queer/questioning, and more

whose initial ART regimen was nonintegrase-based were significantly more likely to have uncontrolled viremia ($p = 0.001$). The type of ART regimen currently used was also associated with viremia control, with higher rates of uncontrolled viremia among those on multi-tablet regimens than those on single-tablet regimens ($p = 0.014$). Finally, patients who experienced ART side effects were significantly less likely to have uncontrolled viremia ($p = 0.038$).

Our t-test analysis revealed a significantly longer duration since HIV diagnosis (73.1 ± 58.8 months) in those with uncontrolled viremia than those without (34.8 ± 33.8 months) ($p = 0.001$). Those with uncontrolled viremia also had a significantly lower nadir CD4 + T-cell percentage (17.2 ± 10.2%) than those without (21.7 ± 10.4%) ($p = 0.001$) Although both absolute CD4 + counts and percentages were analyzed, CD4% was chosen for the final model due to its greater statistical significance and immunological stability in retrospective analysis (Table 4).

Logistic regression analysis revealed that a longer duration since HIV diagnosis increased the odds of uncontrolled viremia by 2% per additional month. Higher nadir

Table 4 Clinical and ART regimen characteristics associated with uncontrolled HIV viremia

Variable	Uncontrolled viremia		Total	p^a
	Yes *n* (%)	No *n* (%)		
Clinical stage of diagnosis				
Stage 1 or 2	84 (67.2)	204 (77.6)	288	**0.029**
Stage 3	41 (32.8)	59 (22.4)	100	
Initial ART regimen				
Integrase-based	101 (80.8)	254 (96.6)	355	**0.001**
Nonintegrase-based	24 (19.2)	9 (3.4)	33	
Multi-tablet	84 (67.2)	153 (58.2)	151	0.088
Single-tablet	41 (32.8)	110 (41.8)	237	
Current ART regimen				
Integrase-based	125 (100.0)	259 (98.5)	384	Ω
Nonintegrase-based	0 (0.0)	4 (1.5)	4	
Multi-tablet	84 (67.2)	142 (54.0)	226	**0.014**
Single-tablet	41 (32.8)	121 (46.0)	162	
ART side effects				
Yes	2 (1.6)	17 (6.5)	19	**0.038**
No	123 (98.4)	246 (93.5)	369	
Variable	**Yes** **Mean ± SD**	**No** **Mean ± SD**		p^b
Duration since HIV diagnosis*	73.1 ± 58.8	34.8 ± 33.8		**0.001**
Baseline HIV RNA count at diagnosis**	1,271,754.5 ± 3,354,014	1,116,721.7 ± 5,482,099.1		0.771
Baseline CD4 + T-cell count***	373.2 ± 299.3	415.0 ± 261.8		0.162
Baseline CD4 + T-cell percentage	23.4 ± 47.6	22.7 ± 10.6		0.802
Nadir CD4 + T-cell count***	334.8 ± 258.6	376.3 ± 235.6		0.117
Nadir CD4 + T-cell percentage	17.2 ± 10.2	21.7 ± 10.4		**0.001**

p^a = chi-square test *p*-value; p^b = student's t-test *p*-value; * (months) **(copies/mL) ***(cells/μL)

Ω = result not reported as the chi-square test assumptions were not met. *P*-values ≤ 0.05 were considered statistically significant and are shown in bold

ART, antiretroviral therapy; HIV, human immunodeficiency virus; RNA, ribonucleic acid; SD, standard deviation

Table 5 Logistic regression analysis of factors related to uncontrolled HIV viremia

		Adjusted OR (95% CI)	*p*-value
Duration since HIV diagnosis		1.02 (1.01–1.03)	**0.001**
Nadir CD4 + T-cell percentage		0.96 (0.93–0.99)	**0.019**
Opportunistic infections			
Reference	Yes	3.25 (1.29–7.14)	**0.009**
	No		
ART side effects			
Reference	No	6.48 (1.33–31.57)	**0.001**
	Yes		

The *p*-values shown are the significance levels found by logistic regression analysis. *P*-values ≤ 0.05 were considered statistically significant. Variables included in the logistic regression analysis were duration of HIV diagnosis, nadir CD4 + T-cell percentage, opportunistic infections, ART side effects, age, education level, stage of diagnosis, initial ART regimen (integrase-based or not), and current ART regimen (single-tablet or multi-tablet)

ART, antiretroviral therapy; CI, confidence interval; HIV, human immunodeficiency virus; OR, odds ratio

CD4 + T-cell percentages exerted protective effects, with each 1% increase reducing the risk of uncontrolled viremia by 4%. The presence of opportunistic infections resulted in 3.25x higher odds of uncontrolled viremia. The likelihood of uncontrolled viremia was 6.5 times greater in those without ART side effects (Table 5).

Discussion

This study demonstrates the impact of sociodemographic (age, education level, place of residence), clinical (presence of opportunistic infections, polypharmacy), and treatment-related (ART regimen type, side effects) factors on unsuppressed viremia among PLWH in Turkiye. Our logistic regression analysis showed that the risk of unsuppressed viremia increases with the duration of HIV diagnosis, the presence of opportunistic infections, the absence of ART side effects, and lower percentages of nadir CD4 + T lymphocytes.

Sociodemographic factors

We found unsuppressed viremia to be more common in older individuals. This can be explained by older patients being more likely to have comorbidities, to have difficulty adhering to treatment, and to be less responsive to treatment [17]. Elvstam et al. demonstrated a lower rate of treatment adherence in older HIV patients [18]. The same finding has been reported in a study conducted in Turkiye [19]. These factors indicate a need for

individualized treatment strategies for older PLWH to help these patients maintain viral suppression and minimize the risk of virological failure.

We found higher rates of unsuppressed viremia among patients with lower education levels. Based on similar findings in other studies, both in Turkiye and internationally [9, 19–21], it seems this is likely due to reduced treatment adherence. Lower education levels may lead to difficulties in understanding and following ART treatment.

The patients in our cohort from Izmir had higher rates of unsuppressed viremia. As this is a larger city than the other two, this could be attributable to increased social and economic stress in these patients. Gökengin et al. reported that PLWH living in large cities in Turkiye had lower adherence rates compared to those in rural areas [9]. Similarly, international studies have shown that HIV patients living in large cities have more difficulty adhering to treatment [22, 23]. It is also important to clarify that all three participating centers—İzmir, Muğla, and Balıkesir—are located in officially designated metropolitan municipalities in Türkiye. While İzmir is notably larger and contributed the majority of the study population, this does not represent a rural–urban contrast. Therefore, the observed association with city size may be influenced by sampling distribution rather than geographic disparities in healthcare access.

Clinical factors

An important finding was that the duration since HIV diagnosis plays a significant role. We found that each additional month increases the likelihood of unsuppressed viremia by 2%. This result aligns with the literature, which suggests that difficulties maintaining virological suppression can arise over a long period due to treatment fatigue, decreased adherence, or accumulated drug resistance [24, 25].

Another significant finding was the protective effects of higher nadir CD4 + T-cell counts against unsuppressed viremia. Specifically, each 1% increase in nadir CD4 + T-cell percentage reduces the risk of uncontrolled viremia by 4%. This finding underscores the importance of early and aggressive intervention to preserve immune function, as higher nadir CD4 + T-cell counts have also been associated with better long-term virological outcomes in previous studies [26, 27]. Maintaining a higher CD4 + T-cell count may contribute to the preservation of immune competence despite fluctuations in viremia.

Of particular note was our finding that the presence of opportunistic infections is associated with a threefold higher risk of uncontrolled viremia. This result is consistent with previous studies, which have suggested that opportunistic infections may disrupt ART adherence, affect drug absorption, and weaken the immune system, thus reducing the effectiveness of ART and leading to virological failure [3, 28]. Opportunistic infections are indicators of advanced disease progression. Thus, these patients are more vulnerable to the risk of virological failure and require closer monitoring and greater intervention [29].

Treatment-related factors

The clinical impact of ART regimen selection is noteworthy. We found integrase-based regimens to be more effective than non-integrase regimens, with those initially treated with an integrase-based ART regimen having lower rates of unsuppressed viremia. The effectiveness of integrase inhibitors in providing virological suppression has previously been demonstrated in HIV treatment protocols both in Turkiye and globally [8, 9]. Elvstam et al. found that integrase-based regimens are more successful in terms of both treatment adherence and virological suppression [18]. Furthermore, our finding that multi-tablet regimens are associated with higher rates of uncontrolled viremia than single-tablet regimens is supported by the previous literature [30], suggesting that the complexity of multi-tablet regimens may reduce adherence and negatively affect virological outcomes. These findings emphasize the importance of using simple regimens whenever possible to improve adherence and optimize long-term virological outcomes.

Interestingly, patients who did not experience ART side effects were found to have a 6.5-fold higher likelihood of uncontrolled viremia. This paradoxical finding can be explained by the fact that individuals experiencing side effects are more closely monitored, leading to better adherence and faster identification of virological issues [31, 32]. Atuhaire et al. reported that patients who experience ART side effects have more frequent contact with their doctors, which improves their treatment adherence [23]. Conversely, patients who do not experience side effects may be more lax in their adherence due to lower perceptions of risk. This highlights the importance of regular follow-up and counseling, even for asymptomatic patients and those who tolerate ART well.

Finally, it is important to note that our definition of uncontrolled viremia included not only virological failure and rebound but also cases of low-level viremia and viral blips. While this may be considered a stricter interpretation, it was intentionally chosen to enhance sensitivity in detecting early risks for virological failure. Recent literature has suggested that even transient or low-level viremia may have prognostic value, particularly in patients with fluctuating adherence or immunological fragility [18, 33, 34]. Our subgroup analyses confirmed that excluding these categories did not substantially alter the main findings, supporting the robustness of our results.

Limitations

This study has some limitations. The retrospective design prevented the determination of causal relationships. Additionally, the data were collected from only three cities in the Aegean region of Turkiye, limiting the generalizability of our findings. The majority of the participants were male, with some age groups more highly represented, limiting sex and age diversity. Some variables, such as substance use and ART adherence, were based on patient reports, which may have influenced data accuracy. Psychosocial factors, such as mental health status and social support, and their impact on ART adherence and virological suppression were not addressed. The unexpected relationship between ART side effects and better virological outcomes may be explained by closer clinical monitoring, but further investigation is needed. In the absence of standardized adherence data, this association might also be indicative of lower adherence among patients who are less engaged with routine care. To improve treatment adherence and virological success, future studies should explore these issues in more detail, addressing these limitations.

Conclusions

This multicenter study identified four independent predictors of unsuppressed HIV viremia in people living with HIV in Turkiye. Longer duration since HIV diagnosis, lower nadir CD4 + T-cell percentages, presence of opportunistic infections, and absence of ART side effects were significantly associated with virological failure. These findings emphasize the need for earlier diagnosis and treatment initiation, consistent immune monitoring, and close follow-up—especially in patients with prolonged disease duration or immunosuppression. Proactive management of opportunistic infections and routine clinical engagement, even in asymptomatic individuals, may help improve long-term virological outcomes. These results offer valuable evidence for refining HIV treatment and monitoring strategies in similar care settings.

Abbreviations

ART	Antiretroviral therapy
PLWH	People living with HIV

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Author contributions

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Data availability

The data presented in this study are available on request from the corresponding author.

Declarations

Ethics approval and consent to participate

The research received ethical approval from the ethics committee of Tepecik Training Hospital (approval date/number: 04.06.2024/05–02) and the hospital administration overseeing the recruitment of participants. This study was conducted in accordance with the principles of the Declaration of Helsinki. Informed Consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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