J MEDICINE 2026; 27: 94-101

Original Article

Effect of Tenofovir on Renal Function among Bangladeshi Adults on Long-term Antiretroviral Therapy: A Cross-sectional Study

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Abstract

Background: *Tenofovir disoproxil fumarate (TDF) is widely used in first-line antiretroviral therapy (ART) and is effective against HIV and hepatitis B, but its long-term impact on renal function is a concern. We aimed to compare renal function in HIV-positive Bangladeshi adults on TDF-containing versus non-TDF ART regimens.*

Methods: *This cross-sectional study was conducted at the Antiretroviral Therapy (ART) Center of Bangladesh Medical University (BMU), Dhaka. Participants were people living with HIV (PLHIV) who had been receiving ART for six months or longer. Current clinical and laboratory data were collected at a single study visit, while baseline data recorded prior to ART initiation were retrieved from the center's medical records. We recruited 100 HIV-infected adults (age ≥18) on ART for ≥6 months, excluding those with diabetes, hypertension, chronic kidney disease, or Non-Steroidal Anti-Inflammatory Drug (NSAID) use. Seventy patients were on TDF-containing regimens and 30 on non-TDF regimens. Serum creatinine was measured, and estimated glomerular filtration rate (eGFR) was calculated by the Modification of Diet in Renal Disease (MDRD) formula. Baseline creatinine/eGFR (at ART initiation) were obtained from records. Renal function between groups and changes from baseline within groups were analyzed using t-tests.*

Results: *The participants' mean age was 36.7 years; 74% were male. After a mean of 23 months on ART, there was no significant difference in mean eGFR between the TDF and non-TDF groups (101.2 ± 27 vs 103.3 ± 28 mL/min/1.73m², p = 0.73). Only 2 patients (both in the TDF group) had eGFR <60. Within the TDF group, eGFR declined from a baseline mean of 107.9 to 101.2 (p = 0.036), with a corresponding rise in serum creatinine (0.83 to 0.90 mg/dL, p = 0.002). No significant change in renal function from baseline was observed in the non-TDF group.*

Conclusions: *Long-term TDF therapy was not associated with significantly worse renal function compared to non-TDF regimens in this cohort, although a mild decline in eGFR was noted in TDF-treated patients. Regular monitoring of renal function is advisable for patients on TDF. Larger longitudinal studies are recommended to confirm the long-term renal safety of TDF.*

Keywords: *Tenofovir, Renal function, AIDS, HIV, Antiretroviral.*

DOI: *https://doi.org/10.3329/jom.v27i2.92269*

Received: *20-04-2026;* ***Accepted:*** *13-06-2026*

Introduction

Acquired immunodeficiency syndrome (AIDS) is caused by the human immunodeficiency virus (HIV). There are two main types of HIV (HIV-1 and HIV-2), with HIV-1 being more virulent and globally prevalent[13]. The HIV-1 group M pandemic is believed to have originated from cross-species transmission in Central Africa in the 1920s[12,14].

Effective treatment of HIV infection requires combination antiretroviral therapy (ART) to achieve durable viral suppression and prevent the emergence of drug-resistant strains[15]. ART regimens typically consist of three antiretroviral drugs from at least two different classes – often two nucleoside reverse transcriptase inhibitors (NRTIs) plus a third agent such as a non-nucleoside reverse transcriptase

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inhibitor, a protease inhibitor, or an integrase inhibitor[15,19]. This triple-drug approach (commonly known as highly active ART or a "cocktail") has dramatically reduced HIV-related morbidity and mortality since its introduction in the mid-1990s[20]. The rationale for combination therapy lies in HIV's rapid replication cycle and high mutation rate[16,17], which would quickly lead to drug resistance if monotherapy were used[18]. Current evidence also supports early initiation of ART: starting treatment in all HIV-positive individuals regardless of CD4 count leads to better health outcomes[21]. Accordingly, global guidelines now recommend treating all patients as soon as HIV is diagnosed (the "Treat All" strategy), often using tenofovir-based regimens as first-line therapy[21,22].

Tenofovir disoproxil fumarate (TDF) is a nucleotide analogue reverse transcriptase inhibitor that has become a cornerstone of first-line ART worldwide[22]. TDF's popularity is due to its potent antiviral efficacy against HIV (and hepatitis B virus) and its convenient once-daily dosing, made possible by a long intracellular half-life[1,2,23]. However, TDF has been associated with nephrotoxicity in some patients, manifesting as a decline in glomerular filtration rate (GFR), proximal tubular dysfunction (Fanconi syndrome), or even acute kidney injury[1,3,24]. The mechanisms are thought to involve tenofovir accumulation in renal proximal tubular cells, leading to cellular damage[1].

Multiple studies have examined the impact of TDF on renal function, with mixed findings. Some reports indicate that kidney function markers can deteriorate within the first year of TDF therapy in susceptible individuals[5,6]. For example, a randomized trial found evidence of proximal tubular dysfunction developing over 48 weeks in patients on TDF-containing ART[5]. Observational studies in routine clinical settings have noted TDF-associated renal impairment occurring at a median of about 5–7 months after TDF initiation[6,7]. On the other hand, the incidence of severe renal impairment attributable to TDF appears to be low in most cohorts. In a South African ART program, only 1.3% of patients on TDF developed severe renal impairment, with 13.1% developing moderate impairment[8]. Similarly, an HIV clinic in Kenya reported that 11.5% of patients (most of whom were on ART) had evidence of renal dysfunction[9]. Importantly, some large-scale studies have not found a significant long-term difference in renal outcomes between TDF-containing regimens and other treatments[10,11]. The DART trial in Africa observed no significant difference in the incidence of severe decline in kidney function over 4–5 years between patients receiving TDF-containing ART and those on non-TDF regimens, except that individuals who began TDF with pre-existing low eGFR had a higher risk of subsequent renal impairment[10]. Likewise, a meta-analysis of clinical trials did not detect an overall increased risk of chronic kidney disease, proteinuria, or hypophosphatemia in HIV patients on TDF compared to alternative therapies[11]. Consistent with these findings, a 10-year observational cohort in Canada reported that the cumulative loss of kidney function attributable to TDF was relatively modest over a decade of use[4].

Most of the above studies were conducted in North American, European, or African populations. Data on the long-term renal effects of TDF in Asian populations, including Bangladesh, remain limited. To date, no published study has specifically evaluated the impact of TDF on renal function among HIV-positive patients in Bangladesh. Given the increasing use of TDF-based first-line ART in our country and the potential for drug-related nephrotoxic effects, it is important to investigate TDF's safety profile in our context.

The present study was designed to compare renal function in Bangladeshi adults on long-term TDF-containing ART versus those on non-TDF ART, and to determine whether TDF use is associated with changes in renal function (as measured by eGFR) after at least six months of therapy.

Materials and Methods

Study Design and Setting: We conducted a cross-sectional study at the ART Center of BMU in Dhaka, Bangladesh. Ethical approval was obtained from the institutional review board of BMU and informed written consent was taken from all participants.

Study Population: This cross-sectional study was conducted at the ART Center of BMU, Dhaka. Participants were people living with HIV (PLHIV) who had been receiving ART for six months or longer. Current clinical and laboratory data were collected at a single study visit, while baseline data recorded prior to ART initiation were retrieved from the center's medical records We enrolled a total of 100 eligible patients by convenience sampling. Among these, 70 patients were receiving TDF-containing ART (Group A) and 30 were on non-TDF regimens (Group B). We defined two groups of patients based on their ART regimen: Group A comprised those on a TDF-containing regimen, and Group B included those on an ART regimen not containing TDF. We excluded individuals with known diabetes mellitus, hypertension, chronic kidney disease, or regular non-steroidal anti-inflammatory drug (NSAID) use, in order to avoid confounding factors that could independently affect renal function.

Data Collection: We used a structured questionnaire and patient medical records to collect data on demographics, clinical history, and treatment details. Baseline laboratory values (at the time of ART initiation) were recorded from

the patients' files, including serum creatinine and CD4+ T-cell count. Current serum creatinine was measured at the study visit for all participants using standard laboratory methods. Body weight was measured at baseline and at follow-up for descriptive purposes.

Assessment of Renal Function: Renal function was evaluated in terms of the estimated glomerular filtration rate (eGFR). eGFR was calculated from serum creatinine values using the four-variable Modification of Diet in Renal Disease (MDRD) equation, expressed in mL/min per 1.73 m². For the purposes of analysis, impaired renal function was defined as eGFR < 60 mL/min/1.73 m², which corresponds to at least moderate renal impairment. We compared current eGFR between Group A (TDF) and Group B (non-TDF). Additionally, for each group we compared the current eGFR to the baseline eGFR (collected at ART initiation) to assess any change over time.

Statistical Analysis: Data were entered and analyzed using IBM SPSS software version 26. Continuous variables (such as age, CD4 count, creatinine, eGFR) were summarized as mean ± standard deviation. Categorical variables (such as sex, presence of co-infections) were summarized as frequencies and percentages. The two groups were compared using the chi-square test for categorical variables and independent-samples *t*-test for continuous variables. Paired *t*-tests were used to compare baseline and follow-up renal function within the same individuals. One-way ANOVA was performed to explore differences in renal function across different durations on ART. A p value < 0.05 was considered statistically significant for all analyses.

Results

Participant Characteristics: A total of 100 HIV-positive adults on long-term ART were included in the analysis (70 in the TDF group and 30 in the non-TDF group). The age of participants ranged from 22 to 58 years, with a mean age of 36.68 ± 8.95 years. The majority (44%) were between 31–40 years old. Men constituted 74% reflecting the higher proportion of males in the clinic population, while 26% were female. Most participants were married (86%) and employed in various occupations; about 22% were housewives and 26% had service jobs, among other professions. Socioeconomic data indicated that 81% had a monthly income above 30,000 Bangladeshi Taka(BDT). The TDF and non-TDF groups were generally similar in baseline demographic and clinical characteristics. There were no significant differences between the groups in terms of age distribution or sex ratio. The mean baseline CD4+ T-cell count of the entire cohort was 456 ± 278 cells/μL. Patients in the non-TDF group had a higher baseline mean CD4 count (602 cells/μL) compared to those in the TDF group (394 cells/μL), but this difference was not statistically significant (p = 0.472).

All patients had normal baseline renal function before starting ART. The overall mean baseline serum creatinine was 0.81 ± 0.11 mg/dL and the mean baseline eGFR was 109.35 ± 16.91 mL/min/1.73m². There were no significant differences between the TDF and non-TDF groups in baseline renal parameters: baseline eGFR was 107.9 ± 15.7 in the TDF group vs 112.8 ± 19.3 mL/min/1.73m² in the non-TDF group (p = 0.19), and baseline creatinine was 0.83 ± 0.11 vs 0.79 ± 0.12 mg/dL, respectively (p = 0.16). (Table :1)

Table 1: *Socio-demographic characteristics of the study cohort*

Characteristics	All participants	TDF exposure	
	n (%)	TDF ART n (%)	Non-TDF ART n (%/)
All	100	70 (70)	30 (30)
Socio-demographic/economic			
Age (years)			
22-30	28 (28)	21 (30)	7 (23.3)
31-40	44 (44)	32 (45.7)	12 (40)
41-50	20 (20)	14 (20)	6 (20)
51-58	8 (8)	3 (4.3)	5 (16.6)
Sex			
Male	74 (74)	52(74.3)	22 (73.3)
Female	26 (26)	18 (25.7)	8 (26.7)
Educational status			
No formal education	3(3)	3 (4.3)	0 (0)
Primary	34 (34)	23 (32.9)	11 (36.7)
Secondary	39 (39)	28 (40)	11 (36.7)
Higher secondary	11 (11)	7 (10)	4 (13.3)
Graduate	13 (13)	9 (12.9)	4 (13.3)
Occupation			
Service	26 (26)	15 (21.4)	11 (36.7)
Business	11 (11)	8 (11.4)	3 (10)
Housewife	22 (22)	16 (22.9)	6 (20)
Unemployed	28 (28)	22 (31.4)	6 (20)
Driver	5 (5)	5 (7.1)	0 (0)
Day laborer	3 (3)	1 (1.4)	2 (6.7)
Student	2 (2)	1 (1.4)	1 (3.3)
Sex worker (MSM)	2 (2)	1 (1.4)	1 (3.3)
Barber	1 (1)	1 (1.4)	0 (0)
Marital status			
Married	86 (86)	59 (84.3)	27 (90)
Unmarried	13 (13)	10 (14.3)	3 (10)
Widow	1 (1)	1 (1.4)	0 (0)
Monthly income			
≤30,000 BDT	19 (19)	12 (17.1)	7 (23.3)
>30,000 BDT	81 (81)	58 (82.9)	23 (76.7)

Renal Function Outcomes: The patients had been on ART for durations ranging from 6 months to over 24 months at the time of evaluation (mean duration 23.2 ± 21.0 months on therapy). Current laboratory measurements showed a slight increase in serum creatinine and corresponding decrease in eGFR compared to baseline in the overall cohort. The mean serum creatinine at the follow-up point was 0.89 ± 0.21 mg/dL, and the mean eGFR was 101.83 ± 27.15 mL/min/1.73m² for all participants combined.

When comparing between the two regimen groups, we found no significant difference in renal function. Patients on TDF-containing regimens had a mean serum creatinine of 0.90 ± 0.21 mg/dL, virtually the same as the 0.87 ± 0.22 mg/dL in patients on non-TDF regimens (p = 0.472). Mean eGFR in the TDF group was 101.20 ± 26.95 mL/min/1.73m², which was very close to the mean eGFR of 103.30 ± 28.01 mL/min/1.73m² in the non-TDF group (p = 0.725). In other words, after an average of about two years on ART, renal function was comparable between those receiving TDF and those not receiving TDF. Additionally, no participant in the non-TDF group had an eGFR drop below 60 (the threshold for moderate impairment), and only 2 patients in the TDF group (2.9% of that group) had an eGFR < 60 mL/min/1.73m² at the time of follow-up. This suggests that clinically significant renal impairment was uncommon in our cohort.(Table :2). There is no significant relationship found among duration of TDF ART and Non-TDF ART (Table :3).

Changes in eGFR from Baseline: Although the cross-sectional comparison between groups did not show a difference, we did observe changes in renal function within the TDF group over time. Among patients on TDF-based ART, the mean eGFR decreased from 107.89 ± 15.68 mL/min/1.73m² at baseline to 101.20 ± 26.95 mL/min/1.73m² at the follow-up (p = 0.036 by paired t-test). Correspondingly, the mean serum creatinine in the TDF group rose from 0.83 ± 0.11 mg/dL at baseline to 0.90 ± 0.21 mg/dL at follow-up (p = 0.002). These changes indicate a slight but statistically significant deterioration in renal function over the treatment period in the TDF-exposed group. In contrast, the non-TDF group did not show a significant change in renal indices from baseline to follow-up. The mean eGFR in the non-TDF group was 112.76 ± 19.34 at baseline vs 103.30 ± 28.01 mL/min/1.73m² at follow-up (p = 0.063), and mean serum creatinine was 0.79 ± 0.12 vs 0.87 ± 0.22 mg/dL (p = 0.052). While there was a trend toward higher creatinine and lower eGFR in the non-TDF group as well, these changes did not reach the conventional level of statistical significance.

Table 2: Laboratory parameters: comparison of laboratory parameters among TDF ART and Non-TDF ART participants

Laboratory Parameters	Total n (%)	TDF ART n (%)	Non-TDF ART n (%)	P-value
Baseline CD4 count	456.58 ± 277.63	394.36 ± 214.47	601.77 ± 350.05	0.472*
Serum creatinine (mg/dl)				
Baseline	0.81 ± 0.11	0.83 ± 0.11	0.79 ± 0.12	0.157*
After e" 6 months	0.89 ± 0.21	0.90 ± 0.21	0.87 ± 0.22	0.472*
eGFR (ml/min/1.73m²)				
Baseline	109.35 ± 16.91	107.89 ±15.68	112.76 ± 19.34	0.187*
After e" 6 months	101.83 ± 27.15	101.20 ± 26.95	103.30 ± 28.01	0.725*
Duration of ART (months)				
6-12	32 (32)	32 (45.7)	0 (0)	
13-24	44 (44)	28 (40)	16 (53.3)	
>24	24 (24)	10 (14.3)	14 (46.7)	
Mean ± SD	23.18 ± 20.97	20.72 ± 21.34	28.90 ± 19.23	0.074*

*Paired T-test performed to determine significant P-value

Table 3 : Duration of TDF ART and Non-TDF ART Participants

(months)	Total n (%)	TDF ART n (%)	Non-TDF ART n (%)	P-value
6-12	32 (32)	32 (45.7)	0 (0)	
13-24	44 (44)	28 (40)	16 (53.3)	
>24	24 (24)	10 (14.3)	14 (46.7)	
Mean ± SD	23.18 ± 20.97	20.72 ± 21.34	28.90 ± 19.23	0.074

Table 4: Comparison among TDF ART and Non-TDF ART Participants

Participants	Baseline	After ≥6 months	6-12 months	13-24 months	>24 months	P-value
Serum creatinine (mg/dl)						
Totaln (%)	0.81 ± 0.11	0.89 ± 0.21				<0.001
			0.85 ± 0.18	0.97 ± 0.24	0.88 ± 0.21	0.060
TDF ARTn (%)	0.83 ± 0.11	0.90 ± 0.21				0.002
			0.85 ± 0.18	0.98 ± 0.23	0.89 ± 0.11	0.032
Non-TDF ARTn (%)	0.79 ± 0.12	0.87 ± 0.22				0.052
				0.61 ± 0.00	0.88 ± 0.22	0.244
eGFR (ml/min/1.73m²)						
Totaln (%)	109.35±16.91	101.83 ± 27.15				0.005
			107.55 ± 28.11	95.41 ± 27.36	100.88 ± 25.18	0.188
TDF ARTn (%)	107.89±15.68	101.20 ± 26.95				0.036
			107.55 ± 28.11	92.89 ± 24.19	99.00 ± 22.99	0.089
Non-TDF ARTn (%)	112.76 ± 19.34	103.30 ± 28.01				0.063
				166.00 ± 0.00	101.14 ± 25.84	0.020

We also analyzed renal function changes stratified by the duration of ART exposure (6–12 months, 13–24 months, and >24 months on therapy). In the TDF group, the average eGFR after 6–12 months was 107.6 mL/min, after 13–24 months was 92.9 mL/min, and after >24 months was 99.0 mL/min, but the differences among these subgroups were not statistically significant (ANOVA $p = 0.089$). In the non-TDF group, there was a significant difference in eGFR across the three duration categories (ANOVA $p = 0.020$); however, this appeared to be influenced by one outlier case with unusually high eGFR in the shortest duration subgroup (the 6–12 month subgroup in non-TDF had an average eGFR of 166 mL/min based on a single patient, which skewed the results). Overall, we did not observe a clear progressive decline in eGFR with longer treatment duration in either group within the timeframe of our study.(Table :4)

Other Clinical Findings: Apart from renal function, we noted that patients on ART tended to gain weight over time. The average body weight of participants at baseline was 59.0 ± 10.2 kg, which increased to 60.2 ± 9.3 kg after at least 6 months of therapy. The weight gain was more pronounced in the non-TDF group (mean gain ~2.4 kg) compared to the TDF group (mean gain ~0.7 kg), although we did not formally test this difference. The improvement in weight likely reflects the overall health benefits of ART. A small number of patients (7%) had a history of opportunistic infections such as tuberculosis, but all were on appropriate treatment and these infections were not active at the time of the study. Co-infection with hepatitis B or C was present in 7% of participants; co-infected patients were distributed in the TDF group, where TDF would also be active against HBV.

Discussion

In this cross-sectional study of HIV-infected adults on long-term ART in Bangladesh, we found that TDF-containing regimens did not result in worse renal function compared to non-TDF regimens. After an average of roughly two years on therapy, the two groups had similar mean eGFR and serum creatinine levels. This suggests that TDF, when used in a real-world clinical setting with regular monitoring, may not cause significant renal impairment in the majority of patients over the mid-term. However, we did observe a modest but statistically significant decline in eGFR from baseline among those on TDF, whereas no significant change was seen in patients on non-TDF regimens. This finding raises the possibility that TDF has a mild cumulative nephrotoxic effect over time, even if it does not lead to large differences between groups in the short term.

Our results are in line with several studies reported in other settings. Salome et al. conducted a similar cross-sectional analysis in Uganda involving 953 adults on ART for at least 6 months (median duration ~9.3 years) and found no significant difference in renal function between patients receiving TDF and those on non-TDF regimens.[25] Notably, that study used multiple measures of kidney function (including eGFR, proteinuria, and fractional phosphate reabsorption) and still observed no major between-group differences, reinforcing the idea that TDF's impact on renal function may be minimal for many patients in the absence of other risk factors. Likewise, an observational cohort study by Laprise et al. with up to 10 years of follow-up reported that the loss of kidney function attributable to TDF was relatively small (on the order of a few mL/min per year)[4].

Such long-term data suggest that while TDF can cause a decline in renal function, the magnitude of this effect is usually modest for most patients, especially those without pre-existing renal disease.

On the other hand, our finding of a slight decline in eGFR within the TDF group concurs with reports that TDF does have some nephrotoxic potential. Patel et al. observed that TDF-based treatment was associated with mild renal dysfunction in an Indian cohort, although the dysfunction was often reversible after stopping TDF[6]. Another study documented cases of Fanconi syndrome and acute kidney injury developing within the first year of TDF therapy[7]. The fact that we detected a statistically significant change in eGFR in TDF users (despite a relatively small sample and moderate exposure duration) underscores that the drug can affect kidney function, even if the effect is subtle in the short term. Importantly, the non-TDF group in our study did not show a significant change in eGFR over time, which supports the inference that TDF was likely responsible for the modest renal function decline observed in the TDF group. It is also reassuring that only 2 out of 70 TDF-treated patients (about 3%) developed an eGFR below 60 mL/min/1.73m². This rate of moderate impairment is comparable to other cohorts and indicates that severe nephrotoxicity is infrequent with proper patient selection and monitoring.

Several factors might explain why we did not see a larger impact of TDF on renal function. First, the duration of TDF exposure in our participants was limited (mean around 2 years). Significant TDF-associated nephropathy might require longer cumulative exposure in many cases. Studies that identified more pronounced renal issues often involved longer follow-up or higher-risk populations[4,25]. Second, we excluded individuals with comorbid conditions like diabetes or hypertension, who are known to be at greater risk for kidney disease. Our cohort was relatively healthy aside from HIV infection, which may have protected against kidney injury and reduced background noise in detecting TDF's effect. Third, concomitant use of other potentially nephrotoxic agents (such as certain antibiotics, antivirals like amphotericin, or NSAIDs) was minimal in our sample due to exclusion criteria and standard care practices. This may have prevented some renal harm that could be mistakenly attributed to TDF. Lastly, genetic and environmental factors in our population might influence susceptibility to TDF toxicity; for example, certain polymorphisms in transport proteins have been linked to tenofovir clearance rates and toxicity risk, though investigating these was beyond our scope.

Our study has several strengths. We included a control group of patients on non-TDF regimens, allowing a direct comparison to isolate the effect of TDF. We also had access to baseline kidney function data for each patient, enabling us to assess changes over time within individuals. This paired analysis provides a clearer picture of renal function trajectory under TDF. Furthermore, our exclusion of major confounding comorbidities helps attribute any observed changes more specifically to TDF or ART effects.

We acknowledge some important limitations. First, the sample size (especially the non-TDF group with only 30 patients) was relatively small. A larger sample might have provided greater power to detect small differences or rare outcomes. Second, the duration of follow-up was limited; many patients had been on TDF for only 1–2 years, which may be insufficient to capture long-term renal adverse effects that manifest over many years. Third, this was a single-center study at a national tertiary care clinic, which may limit the generalizability of results to other settings (for example, primary care or rural clinics in Bangladesh) where patient populations or monitoring practices might differ. Fourth, we evaluated renal function primarily via serum creatinine-based eGFR. We did not measure urinary protein, glucosuria, or serum phosphate, which are more sensitive indicators of proximal tubular dysfunction. It is possible that subclinical tubular effects of TDF occurred without an overt change in eGFR in some patients[25]. Finally, as a cross-sectional study, we can identify associations but cannot definitively establish causality or the temporal pattern of changes. A decline in eGFR in the TDF group suggests an effect of TDF, but longitudinal studies are needed to confirm this trend and determine if eGFR continues to drop or stabilizes with longer use.

Conclusion

TDF-based antiretroviral therapy was not associated with significantly worse renal function compared to non-TDF regimens in HIV-positive Bangladeshi adults over an average of two years of treatment. While TDF use did correlate with a small decline in eGFR from baseline, the overall renal function remained within normal ranges for the vast majority of patients. Our findings support the continued use of TDF in first-line ART in settings similar to ours, with the caveat that renal function should be monitored periodically, especially in those with additional risk factors for kidney disease. We recommend further research in larger, multi-center cohorts and prospective longitudinal studies to better elucidate the long-term renal safety of TDF. Such studies should include a more comprehensive assessment of kidney health (including markers of tubular function) and evaluate outcomes over a longer duration of TDF exposure.

Acknowledgements

We are grateful to the authorities, employees, and staff of ART center of BMU for their sincerity and wholehearted cooperation. We acknowledge the use of Grammarly AI to assist with English language editing, improving sentence structure, grammar, and vocabulary for greater clarity. We critically reviewed and revised all generated suggestions to ensure the manuscript's reliability, precision, and integrity. We take full responsibility for the content of this study

Funding

We have not received any funds for this study.

Conflict of interest

We do not have any conflicts of interest.

Ethical approval

Ethical approval was obtained from the Institutional Review Board of BMU.

Data availability statement

We confirm that the data supporting the findings of this study will be shared upon reasonable request.

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