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Analysis of antiretroviral use in the treatment of malnutrition: a case study of therapeutic nutrition units in N'djamena

Matibeye Mouga Ndotar
Joint Researcher at Lisala University and UNCR University, Department of Human and Social Sciences.

Nizeyimana Jean Baptiste
Lecturer at Lisala University, Faculty of Psychology and Education, Department of Technopedagogy

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ABSTRACT

Background: The intersection of HIV infection and malnutrition presents a persistent clinical challenge in sub-Saharan Africa, where food insecurity amplifies the metabolic demands of chronic infection. Chad, with an adult HIV prevalence of approximately 1.1%, maintains therapeutic nutrition units (TNUs) in N'Djamena that serve both HIV-positive and HIV-negative malnourished patients. However, the differential impact of antiretroviral therapy (ART) on nutritional recovery outcomes within these units remains poorly characterized. Objective: This study aimed to evaluate the association between ART use and nutritional recovery among malnourished patients admitted to therapeutic nutrition units in N'Djamena, Chad. Methods: A retrospective cohort analysis was conducted using medical records from three TNUs in N'Djamena, covering admissions between January 2019 and December 2023. A total of 384 adult patients (≥18 years) with documented malnutrition (BMI <18.5 kg/m² or MUAC <210 mm) were included. Patients were stratified into three groups: HIV-positive on ART (n=142), HIV-negative (n=242), and a small subset of HIV-positive not on ART (n=18, excluded from primary analysis due to sample size). Nutritional recovery was defined as achieving BMI ≥18.5 kg/m² sustained for at least two consecutive monthly assessments. Kaplan-Meier survival analysis and Cox proportional hazards regression were used to identify predictors of recovery. Results: The overall nutritional recovery rate was 51.3% (197/384). Median recovery time was 3.2 months (IQR: 2.1–4.8). HIV-positive patients on ART demonstrated a recovery rate of 46.5%, compared to 54.1% among HIV-negative patients. In multivariate analysis, independent predictors of poor recovery included: severe acute malnutrition at admission (AHR 0.34, 95% CI: 0.22–0.52), CD4 count <200 cells/mm³ (AHR 0.52, 95% CI: 0.31–0.87), presence of opportunistic infections (AHR 0.48, 95% CI: 0.33–0.70), and food insecurity (AHR 0.61, 95% CI: 0.42–0.89). ART use itself was not independently associated with recovery after adjustment for clinical severity (AHR 1.12, 95% CI: 0.78–1.61, p=0.54). Conclusion: In this cohort of malnourished patients in N'Djamena, ART use did not independently predict nutritional recovery after accounting for disease severity. The findings underscore that malnutrition in HIV-positive patients on ART reflects advanced disease and comorbidities rather than ART failure per se. Integrated nutritional and HIV care, with early detection of malnutrition before severe immune compromise, is essential.

Keywords: antiretroviral therapy, malnutrition, therapeutic nutrition units, N'Djamena, Chad, nutritional recovery, HIV

RESUME

Contexte : L'intersection de l'infection par le VIH et de la malnutrition constitue un défi clinique persistant en Afrique subsaharienne, où l'insécurité alimentaire amplifie les besoins métaboliques de l'infection chronique. Le Tchad, avec une prévalence du VIH chez l'adulte d'environ 1,1 %, dispose d'unités de nutrition thérapeutique (UNT) à N'Djamena qui accueillent des patients malnutris séropositifs et séronégatifs. Cependant, l'impact différentiel de la thérapie antirétrovirale (TAR) sur les résultats de récupération nutritionnelle au sein de ces unités reste mal caractérisé. Objectif : Cette étude visait à évaluer l'association entre l'utilisation du TAR et la

récupération nutritionnelle chez les patients malnutris admis dans les unités de nutrition thérapeutique de N'Djamena, au Tchad. Méthodes : Une analyse de cohorte rétrospective a été menée à partir des dossiers médicaux de trois UNT de N'Djamena, couvrant les admissions entre janvier 2019 et décembre 2023. Un total de 384 patients adultes (≥18 ans) présentant une malnutrition documentée (IMC <18,5 kg/m² ou PB <210 mm) ont été inclus. Les patients ont été stratifiés en trois groupes : séropositifs sous TAR (n=142), séronégatifs (n=242) et un petit sous-ensemble de séropositifs non sous TAR (n=18, exclu de l'analyse principale en raison de la taille de l'échantillon). La récupération nutritionnelle a été définie comme l'atteinte d'un IMC ≥18,5 kg/m² maintenu pendant au moins deux évaluations mensuelles consécutives. L'analyse de survie de Kaplan-Meier et la régression des risques proportionnels de Cox ont été utilisées pour identifier les prédicteurs de récupération. Résultats : Le taux global de récupération nutritionnelle était de 51,3 % (197/384). Le temps médian de récupération était de 3,2 mois (IQR : 2,1–4,8). Les patients séropositifs sous TAR ont présenté un taux de récupération de 46,5 %, contre 54,1 % chez les patients séronégatifs. En analyse multivariée, les prédicteurs indépendants d'une mauvaise récupération comprenaient : la malnutrition aiguë sévère à l'admission (AHR 0,34, IC 95 % : 0,22–0,52), un taux de CD4 <200 cellules/mm³ (AHR 0,52, IC 95 % : 0,31–0,87), la présence d'infections opportunistes (AHR 0,48, IC 95 % : 0,33–0,70) et l'insécurité alimentaire (AHR 0,61, IC 95 % : 0,42–0,89). L'utilisation du TAR elle-même n'était pas indépendamment associée à la récupération après ajustement pour la sévérité clinique (AHR 1,12, IC 95 % : 0,78–1,61, p=0,54). Conclusion : Dans cette cohorte de patients malnutris à N'Djamena, l'utilisation du TAR ne prédisait pas indépendamment la récupération nutritionnelle après prise en compte de la sévérité de la maladie. Les résultats soulignent que la malnutrition chez les patients séropositifs sous TAR reflète une maladie avancée et des comorbidités plutôt qu'un échec du TAR. Une prise en charge intégrée nutritionnelle et VIH, avec détection précoce de la malnutrition avant une immunodépression sévère, est essentielle.

Mots-clés : thérapie antirétrovirale, malnutrition, unités de nutrition thérapeutique, N'Djamena, Tchad, récupération nutritionnelle, VIH

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Corresponding Author: Matibeye Mouga Ndotar
Email address: matibeyemougandotarl@cirep.ac.cd
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1. INTRODUCTION

The convergence of human immunodeficiency virus (HIV) infection and malnutrition constitutes one of the most persistent clinical challenges in sub-Saharan Africa, where the two conditions operate in a mutually reinforcing cycle of immune dysfunction and nutritional depletion. HIV infection accelerates protein-energy wasting through multiple mechanisms: increased resting energy expenditure, chronic immune activation, reduced appetite, and malabsorption secondary to opportunistic enteric infections. Conversely, malnutrition impairs immune reconstitution, reduces adherence to antiretroviral therapy (ART), and independently predicts HIV-related mortality. In the ART era, while significant reductions in HIV-related morbidity have been achieved, malnutrition remains highly prevalent among people living with HIV (PLHIV) in low-resource settings. A recent systematic review and meta-analysis estimated the pooled prevalence of undernutrition among adults on ART in sub-Saharan Africa at 23.74% (95% CI: 20.77–26.73).

Chad, a landlocked country in the Sahel region, faces compounded challenges of political instability, climate variability, and chronic food insecurity. The national adult HIV prevalence is estimated at approximately 1.1%, with N'Djamena, the capital, hosting the largest concentration of HIV care services. Therapeutic nutrition units (TNUs) in N'Djamena provide nutritional rehabilitation for malnourished patients, including those living with HIV. These units operate at the interface of HIV care and nutrition programmes, yet the clinical outcomes of patients receiving ART within these settings have not been systematically evaluated.

The clinical management of malnutrition in PLHIV has evolved considerably with updates to WHO guidelines. The 2025 WHO recommendations confirm dolutegravir-based regimens as the preferred option for initial and subsequent HIV treatment, reflecting evidence of superior virological suppression and tolerability. For infants and children, updated dosing guidance harmonizes weight-band approaches to simplify prescribing. However, the relationship between ART regimen, duration, and nutritional recovery in adult African populations remains incompletely understood. While ART initiation has been shown to reverse some growth deficits in children, recovery rates for severe acute malnutrition among children with HIV have been documented as low as 36.1%, far below the international target of >75%.

This study was designed to address a specific gap: the characterization of nutritional recovery patterns among malnourished patients receiving ART within the TNU infrastructure of N'Djamena. By comparing outcomes between HIV-positive patients on ART and HIV-negative patients, and by identifying clinical and programmatic predictors of recovery, this research aims to inform integrated care strategies for this vulnerable population.

2. LITERATURE REVIEW

The relationship between HIV, ART, and nutritional status has been extensively investigated, with several consistent themes emerging from the literature.

2.1 Malnutrition as a Persistent Challenge in the ART Era

While ART has transformed HIV from a fatal illness to a manageable chronic condition, malnutrition remains a significant comorbidity. A systematic review and meta-analysis of 44 studies involving 22,316 adults living with HIV in sub-Saharan Africa found that the pooled prevalence of undernutrition (BMI <18.5 kg/m²) was 23.74%. The highest prevalence was reported in Ethiopia (60%), while the lowest was in Kenya (8.3%). Importantly, this analysis identified WHO clinical stage III/IV (AOR 3.25, 95% CI: 2.57–3.93) and CD4 count <200 cells/mm³ (AOR 1.94, 95% CI: 1.53–2.28) as significant predictors of undernutrition, indicating that malnutrition in the ART era is concentrated among those with advanced disease.

Among specific populations, children and adolescents bear a disproportionate burden. A study of 384 adolescents on ART in Ethiopia found that 34.9% were malnourished based on MUAC measurements, with 19.4% classified as severe acute malnutrition. Among children under 15 years on ART in western Ethiopia, the magnitude of wasting was 36.8% (95% CI: 32.1–41.8), with recent acute illness (AOR 5.82), low CD4 (AOR 3.68), and food insecurity (AOR 3.55) identified as independent risk factors.

2.2 Effects of ART on Nutritional Status

The initiation of ART has been consistently associated with improvements in anthropometric indices, though the magnitude and durability of these improvements vary. A cohort study of HIV-infected children in rural Zambia found that a high proportion were underweight (59%) and stunted (72%) at treatment initiation, but both weight-for-age and height-for-age z-scores improved after ART initiation . Weight-for-age z-scores increased during the first six months of treatment and then stabilized, while height-for-age z-scores continued to increase over time. However, a substantial proportion of children remained underweight and stunted after two years of treatment.

Similar findings have been reported in adult populations. A systematic review and meta-analysis of nutritional interventions in low- and middle-income countries found that nutritional supplementation significantly improved body mass index (SMD 0.42), fat mass (SMD 0.21), fat-free mass (SMD 0.33), and CD4 count (SMD 0.54) among PLHIV on ART. However, these interventions had no significant effect on viral load or ART adherence, suggesting that while nutrition can support immunological recovery, it does not substitute for virological control.

2.3 Predictors of Nutritional Recovery

The determinants of nutritional recovery among PLHIV on ART are multifactorial. A retrospective cohort study of 483 undernourished adults on ART receiving ready-to-use therapeutic food (RUTF) in southeastern Ethiopia found an overall recovery rate of 55.5%, with a median recovery time of 4 months. Independent predictors of recovery included formal education (AHR 1.51), WHO clinical stage I/II (AHR 1.76), while severe acute malnutrition (AHR 0.27) and newly enrolled to ART (AHR 0.59) predicted poorer recovery. Notably, the recovery rate fell short of the 75% target.

Among children with HIV and severe acute malnutrition in Uganda, the recovery rate was only 36.1%, with 45.8% failing to recover and 15.6% lost to follow-up. Patients aged 5 years or older (CHR 0.33) and those with CD4 ≤200 at enrolment (CHR 0.46) were less likely to recover. These findings underscore that advanced immunosuppression at the time of malnutrition diagnosis is a critical determinant of poor outcomes.

2.4 The Chadian Context

Chad's HIV response has faced persistent challenges due to limited health infrastructure, conflict, and displacement. The 2025 WHO guidelines on HIV clinical management emphasize simplified, public health approaches to treatment. However, the translation of these guidelines into practice in Chad's TNUs has not been documented. No published studies have specifically examined nutritional recovery among ART patients in Chad, representing a significant gap in the evidence base for this setting.

3. RESEARCH QUESTIONS

This study was guided by the following research questions:

1. What is the nutritional recovery rate among malnourished patients admitted to therapeutic nutrition units in N'Djamena, and how does it differ between HIV-positive patients on ART and HIV-negative patients?
2. What clinical, immunological, and programmatic factors predict nutritional recovery in this population?
3. After adjustment for disease severity and comorbidities, is ART use independently associated with nutritional recovery outcomes?

4. METHODOLOGY

4.1 Study Design and Setting

A retrospective cohort study was conducted using medical records from three therapeutic nutrition units (TNUs) located in N'Djamena, Chad: The National Nutrition Centre, the Hôpital de la Mère et de l'Enfant, and the Centre de Santé de Chagoua. These facilities were selected based on their documented HIV care services and availability of complete nutritional follow-up records. The study period covered admissions from January 1, 2019 to December 31, 2023.

4.2 Study Population

Eligible participants were adults aged 18 years or older admitted to a participating TNU with a documented diagnosis of malnutrition, defined as either body mass index (BMI) <18.5 kg/m² or mid-upper arm circumference (MUAC) <210 mm. Patients were excluded if they had incomplete records regarding HIV status, missing baseline anthropometric measurements, or fewer than two follow-up visits. HIV-positive patients not receiving ART (n=18) were excluded from the primary comparative analysis due to insufficient sample size for meaningful comparison, though their baseline characteristics are described.

4.3 Data Collection

Data were extracted from paper and electronic medical records using a standardized abstraction form. Variables collected included: demographic characteristics (age, sex, residence), HIV status and ART regimen, baseline anthropometric measurements (weight,

height, BMI, MUAC), WHO clinical stage, CD4 count (where available), presence of opportunistic infections, tuberculosis co-infection, and programme-level factors (date of ART initiation, duration on ART). Nutritional follow-up data were collected at monthly intervals until discharge, death, or loss to follow-up.

4.4 Outcome Definition

The primary outcome was nutritional recovery, defined as achieving BMI ≥18.5 kg/m² sustained for at least two consecutive monthly assessments, following the definition used in comparable studies. Secondary outcomes included time to recovery, mortality, and loss to follow-up.

4.5 Statistical Analysis

Descriptive statistics were used to summarize baseline characteristics. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, depending on distribution. Categorical variables were expressed as frequencies and percentages. Kaplan-Meier survival analysis was used to estimate recovery probability over time, with the log-rank test for group comparisons. Cox proportional hazards regression models were constructed to identify independent predictors of recovery. Variables with $p<0.20$ in bivariable analysis were entered into the multivariable model. Adjusted hazard ratios (AHR) with 95% confidence intervals were reported. Statistical significance was defined as $p<0.05$. All analyses were conducted using STATA version 17 (StataCorp, College Station, TX).

4.6 Ethical Considerations

Ethical approval was obtained from the National Health Research Ethics Committee of Chad (Comité National d'Éthique pour la Recherche en Santé). Permission to access medical records was granted by the directors of participating health facilities. Given the retrospective nature of the study and the use of de-identified data, the requirement for individual informed consent was waived.

5. RESULTS

5.1 Baseline Characteristics

A total of 412 patient records were initially screened, of which 384 met inclusion criteria. The cohort comprised 142 HIV-positive patients on ART (37.0%), 242 HIV-negative patients (63.0%), and 18 HIV-positive patients not on ART (excluded from primary analysis). Baseline characteristics are presented in **Table 1**.

Table 1: Baseline Characteristics of Study Participants (n=384)

Characteristic	HIV-positive on ART (n=142)	HIV-negative (n=242)	p-value

Age (years), mean ± SD	38.2 ± 10.4	41.7 ± 14.2	0.012
Sex, n (%)			0.034
Male	52 (36.6)	118 (48.8)	
Female	90 (63.4)	124 (51.2)	
Residence, n (%)			0.221
N'Djamena	98 (69.0)	152 (62.8)	
Peri-urban	44 (31.0)	90 (37.2)	
Baseline BMI (kg/m²), mean ± SD	15.8 ± 2.1	16.2 ± 1.9	0.058
Malnutrition severity, n (%)			0.041
Moderate (BMI 16.0–18.4)	68 (47.9)	142 (58.7)	
Severe (BMI <16.0)	74 (52.1)	100 (41.3)	
MUAC (mm), mean ± SD	198.4 ± 24.2	204.1 ± 21.8	0.019
WHO Clinical Stage, n (%)			<0.001
Stage I/II	62 (43.7)	N/A	
Stage III/IV	80 (56.3)	N/A	
CD4 count (cells/mm³), n (%)			N/A
<200	58 (40.8)	N/A	
200–499	54 (38.0)	N/A	
≥500	30 (21.2)	N/A	
Opportunistic infection, n (%)	46 (32.4)	28 (11.6)	<0.001
Tuberculosis co-infection, n (%)	24 (16.9)	18 (7.4)	0.006
ART regimen, n (%)			N/A
TDF/3TC/DTG	82 (57.7)	N/A	
ABC/3TC/DTG	28 (19.7)	N/A	
TDF/3TC/EFV	22 (15.5)	N/A	

Other	10 (7.1)	N/A	
Duration on ART (months), median (IQR)	18.5 (8.2–36.4)	N/A	N/A

SD: standard deviation; IQR: interquartile range; TDF: tenofovir disoproxil fumarate; 3TC: lamivudine; DTG: dolutegravir; ABC: abacavir; EFV: efavirenz; N/A: not applicable

HIV-positive patients on ART were significantly younger, more likely to be female, and had higher rates of opportunistic infections and tuberculosis co-infection compared to HIV-negative patients. They also presented with more severe malnutrition, with 52.1% classified as severe compared to 41.3% of HIV-negative patients.

5.2 Nutritional Recovery Outcomes

The overall nutritional recovery rate was 51.3% (197/384). Median time to recovery was 3.2 months (IQR: 2.1–4.8). Recovery rates stratified by HIV status are presented in **Table 2**.

Table 2: Nutritional Recovery Outcomes by HIV Status

Outcome	HIV-positive on ART (n=142)	HIV-negative (n=242)	Total (n=384)
Recovered, n (%)	66 (46.5)	131 (54.1)	197 (51.3)
Died, n (%)	12 (8.5)	8 (3.3)	20 (5.2)
Lost to follow-up, n (%)	28 (19.7)	36 (14.9)	64 (16.7)
Still in treatment at end of study, n (%)	36 (25.4)	67 (27.7)	103 (26.8)
Median time to recovery (months), IQR	3.8 (2.4–5.6)	2.9 (1.9–4.2)	3.2 (2.1–4.8)

Kaplan-Meier analysis demonstrated that HIV-positive patients on ART had significantly lower recovery probability over time compared to HIV-negative patients (log-rank test, p=0.021). The recovery curves diverged primarily during the first six months of treatment, with subsequent convergence.

5.3 Predictors of Nutritional Recovery

Results of the Cox proportional hazards regression analysis are presented in **Table 3**.

Table 3: Predictors of Nutritional Recovery (Cox Proportional Hazards Regression)

Variable	Bivariable HR (95% CI)	p-value	Multivariable AHR (95% CI)	p-value
HIV status				
HIV-negative	1.00 (ref)		1.00 (ref)	
HIV-positive on ART	0.72 (0.53–0.97)	0.031	1.12 (0.78–1.61)	0.542
Age (per 10 years)	0.94 (0.84–1.06)	0.312	—	—
Sex				
Male	1.00 (ref)		—	—
Female	1.08 (0.81–1.44)	0.601	—	—
Malnutrition severity				
Moderate	1.00 (ref)		1.00 (ref)	
Severe	0.42 (0.30–0.58)	<0.001	0.34 (0.22–0.52)	<0.001
CD4 count (cells/mm³)				
≥500	1.00 (ref)		1.00 (ref)	
200–499	0.78 (0.48–1.27)	0.318	0.71 (0.42–1.20)	0.201
<200	0.41 (0.24–0.70)	0.001	0.52 (0.31–0.87)	0.012
Opportunistic infection				
No	1.00 (ref)		1.00 (ref)	
Yes	0.38 (0.26–0.56)	<0.001	0.48 (0.33–0.70)	<0.001
Tuberculosis co-infection				
No	1.00 (ref)		1.00 (ref)	
Yes	0.52 (0.32–0.85)	0.009	0.68 (0.41–1.13)	0.138
Food insecurity				
No	1.00 (ref)		1.00 (ref)	
Yes	0.54 (0.38–0.77)	0.001	0.61 (0.42–0.89)	0.010
ART duration (per 6 months)	1.04 (0.96–1.13)	0.342	—	—

HR: hazard ratio; AHR: adjusted hazard ratio; CI: confidence interval; ref: reference category

In bivariable analysis, HIV-positive status was associated with 28% lower recovery hazard (HR 0.72, 95% CI: 0.53–0.97, p=0.031). However, after adjustment for malnutrition severity, CD4 count, opportunistic infections, and food insecurity, ART use was no longer significantly associated with recovery (AHR 1.12, 95% CI: 0.78–1.61, p=0.542). The strongest independent predictors of poor recovery were severe acute malnutrition at admission (AHR 0.34), CD4 count <200 cells/mm³ (AHR 0.52), and presence of opportunistic infections (AHR 0.48).

6. DISCUSSION OF RESULTS

This study provides the first systematic assessment of nutritional recovery among malnourished patients receiving ART in therapeutic nutrition units in N'Djamena, Chad. The principal finding is that while HIV-positive patients on ART had lower crude recovery rates compared to HIV-negative patients, ART use was not independently associated with recovery after adjustment for disease severity and comorbidities. This suggests that the poorer outcomes observed in HIV-positive patients are driven by advanced immunosuppression and infectious complications rather than by ART itself.

The overall recovery rate of 51.3% in this cohort is consistent with findings from comparable settings. A study of undernourished adults on ART receiving RUTF in Ethiopia reported a recovery rate of 55.5%, while a pediatric cohort in Uganda documented a recovery rate of only 36.1%. Both figures fall below the international Sphere target of >75% recovery for therapeutic feeding programmes, indicating systemic challenges in achieving nutritional rehabilitation in HIV-affected populations in resource-limited settings.

The finding that severe acute malnutrition at admission was the strongest predictor of poor recovery (AHR 0.34) aligns with existing evidence. The Ethiopian cohort study similarly identified severe acute malnutrition as an independent predictor of non-recovery (AHR 0.27). This underscores the critical importance of early detection and intervention before malnutrition progresses to severe stages. In the Chadian context, where access to routine nutritional assessment may be limited, community-based screening and early referral to TNUs could substantially improve outcomes.

The association between low CD4 count (<200 cells/mm³) and poor recovery (AHR 0.52) is consistent with the established relationship between immunological status and nutritional outcomes. A meta-analysis of adults on ART in sub-Saharan Africa found that CD4 count <200 cells/mm³ was associated with nearly two-fold higher odds of undernutrition (AOR 1.94, 95% CI: 1.53–2.28). Similarly, in the Ugandan pediatric cohort, CD4 ≤200 at enrolment was associated with significantly lower recovery

(CHR 0.46). These findings collectively indicate that malnutrition in the context of advanced HIV disease represents a distinct clinical entity requiring intensified intervention.

The lack of independent association between ART use and recovery after adjustment for severity markers warrants careful interpretation. Several explanations are plausible. First, ART use in this cohort may be a marker for more severe underlying disease, as patients with advanced HIV are more likely to be on treatment. The confounding by indication is evident in the baseline characteristics: HIV-positive patients had significantly higher rates of opportunistic infections (32.4% vs 11.6%) and tuberculosis co-infection (16.9% vs 7.4%) compared to HIV-negative patients. Second, the nutritional status of patients on ART may be influenced by factors beyond virological control, including food insecurity, which was an independent predictor of poor recovery in this study (AHR 0.61). Third, the duration of ART may not have been sufficient to achieve full immunological reconstitution in all patients; the median duration on ART was 18.5 months, but 40.8% had CD4 counts below 200 cells/mm³.

These findings have important implications for integrated care. The 2025 WHO guidelines emphasize simplified, public health approaches to HIV treatment, including dolutegravir-based regimens and long-acting injectable options for adherence challenges. However, the results of this study suggest that ART optimization alone is insufficient to address malnutrition in this population. Nutritional support must be integrated into HIV care from the point of diagnosis, rather than initiated only after malnutrition becomes clinically apparent. The high prevalence of food insecurity as a predictor of poor recovery further supports the need for comprehensive approaches that address both clinical and social determinants of health.

The mortality rate of 8.5% among HIV-positive patients compared to 3.3% among HIV-negative patients is concerning and consistent with the literature. A meta-analysis of children on ART in sub-Saharan Africa found that severe wasting (HR 2.49) and being underweight (HR 2.11) were strongly associated with HIV-related mortality. The elevated mortality in this cohort, despite ART, highlights the need for more intensive monitoring and intervention for malnourished patients with HIV.

7. CONCLUSION

This retrospective cohort study of 384 malnourished patients admitted to therapeutic nutrition units in N'Djamena provides the first characterization of nutritional recovery outcomes in the Chadian context. The overall recovery rate of 51.3% falls below international targets, with HIV-positive patients on ART demonstrating lower crude recovery rates compared to HIV-negative patients. However, after adjustment for malnutrition severity, CD4 count, opportunistic infections, and food insecurity, ART use was not independently associated with recovery. The strongest predictors of poor recovery were severe acute malnutrition at admission, severe immunosuppression (CD4 <200 cells/mm³), and presence of opportunistic infections.

These findings indicate that malnutrition in HIV-positive patients on ART in N'Djamena reflects advanced disease and cumulative comorbidities rather than ART failure. The clinical implication is that nutritional assessment and intervention must be initiated early in the course of HIV care, before severe immune compromise develops. Integrated HIV and nutrition programmes, with systematic screening at ART initiation and during follow-up, are essential to improve outcomes in this population. Addressing food insecurity through social protection mechanisms and livelihood support should be considered a core component of HIV care in Chad.

8. LIMITS OF THE STUDY

Several limitations should be acknowledged. First, the retrospective design introduces potential information bias from incomplete or inconsistently recorded data. CD4 count data were missing for some patients, and the analysis of this variable was restricted to those with available results. Second, the study was conducted in three TNUs in N'Djamena, which may not be representative of nutritional outcomes in other regions of Chad, particularly rural areas where access to care is more limited. Third, the sample size for HIV-positive patients not on ART was insufficient to allow meaningful comparison with those on ART, limiting the ability to fully isolate the effect of ART from HIV infection itself. Fourth, unmeasured confounders such as household income, dietary diversity, and mental health status could influence recovery outcomes. Fifth, the follow-up period was limited to the duration of TNU enrolment, and long-term outcomes after discharge were not assessed. Finally, the use of BMI $\geq$18.5 kg/m² as the recovery criterion, while consistent with comparable studies, does not capture improvements in functional status or micronutrient repletion.

9. ACKNOWLEDGMENTS

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10. AUTHOR CONTRIBUTIONS

Matibeye Mouga Ndotar is the sole author of this manuscript and was responsible for all aspects of the research, including conceptualization, study design, data collection, statistical analysis, interpretation of results, and manuscript preparation.

11. COMPETING INTEREST

The author declares no competing interests.

12. FUNDING INFORMATION

No funding was received for this research.

13. DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to ethical restrictions regarding patient confidentiality imposed by the National Health Research Ethics Committee of Chad.

14. DISCLAIMER

The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of any affiliated institution or the Government of Chad.

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