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Nutritional status and dietary adequacy among school-aged children living with HIV on antiretroviral therapy in Nsanje district, Malawi

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Nutritional status and dietary adequacy among school-aged children living with HIV on antiretroviral therapy in Nsanje district, Malawi.

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Abstract

Background: HIV infection remains a major public health challenge in sub-Saharan Africa. Children living with HIV are vulnerable to poor nutritional outcomes, particularly in rural settings affected by food insecurity and climate-related shocks. This study assessed the nutritional status and dietary adequacy of school-aged children living with HIV receiving antiretroviral therapy (ART) in Nsanje District, Malawi.

Methods: A facility-based cross-sectional study was conducted from January to June 2026 among children aged 5–15 years attending Kalemba Mission Hospital. Of 111 children selected, 102 participated, giving a 91.9% recruitment rate. Nutritional status was measured using WHO anthropometric indicators, while dietary intake was assessed using 24-hour recalls, a semi-quantitative food frequency questionnaire, and dietary diversity analysis. The IBM™ SPSS Statistics version 29 was utilised for descriptive and inferential statistics.

Results: Among the 102 children, the mean height-for-age Z-score was −1.74 and the mean BMI-for-age Z-score was −1.21. Stunting affected 44.1% of participants, thinness 35.3%, and overweight 5.9%. Most children (70.6%) had adequate dietary diversity, but 29.4% had low dietary diversity. Energy and protein inadequacy were common, with 67.6% and 58.8% of children falling below the EAR, respectively. Mean NAR was highest for iron (0.91), and overall MAR was 0.783. Low dietary diversity (AOR = 2.41, 95% CI: 1.15–5.08) and unsuppressed viral load (AOR = 3.48, 95% CI: 1.42–8.51) were associated with thinness, while children aged 11–15 years had lower odds of thinness than those aged 5–10 years (AOR = 0.57, 95% CI: 0.30–0.99).

Conclusion: Poor nutritional status remained common despite ART, highlighting the need for routine nutritional screening, dietary counselling, and regular viral load monitoring.

Keywords: *HIV, antiretroviral therapy, nutritional status, dietary adequacy, dietary diversity, thinness, school-aged children, Malawi*

1.1. Introduction

HIV infection remains a major public health challenge in sub-Saharan Africa, and children living with HIV are especially vulnerable to undernutrition because infection can increase metabolic demands, reduce dietary intake and nutrient absorption, and contribute to recurrent illness [1]. Although antiretroviral therapy (ART) has substantially improved HIV-related morbidity and mortality, malnutrition remains an important concern among children receiving treatment [2].

This burden is particularly relevant for school-aged children, a group that has received less attention in paediatric HIV and nutrition research than children under five years [3]. Global estimates indicate that 1.7 million children aged 0-14 years were living with HIV in 2023, with nearly 90% residing in sub-Saharan Africa [2,3]. In this context, inadequate nutrition remains common among school-aged children living with HIV despite improvements in HIV care, with studies from sub-Saharan Africa reporting stunting, thinness, and poor dietary diversity among children receiving ART [2,3]. Because adequate nutrition is central to growth, immune function, and recovery, nutritional assessment and support are essential components of comprehensive paediatric HIV care [4].

Several factors may contribute to poor nutritional outcomes among children living with HIV, including food insecurity, poverty, low dietary diversity, and recurrent infections [5]. Dietary diversity is a practical indicator of diet quality and is associated with macro- and micronutrient adequacy, particularly in low-resource settings [6,7]. Children who consume foods from a limited number of food groups are more likely to have inadequate nutrient intake and poor growth outcomes, while an unsuppressed viral load may further increase nutritional risk through higher metabolic demands and impaired nutrient use [6,7]. These pathways suggest that both dietary and HIV-related clinical factors should be considered when assessing nutritional vulnerability.

Malawi has made important progress in expanding paediatric HIV services, including improved ART coverage and viral suppression among children living with HIV [8]. National guidelines recommend routine growth monitoring, nutritional assessment, annual viral load testing, adherence counselling, and clinical review as part of integrated paediatric HIV

care [9]. In addition, Malawi's National HIV and AIDS Policy 2022–2027 and the Health Sector Strategic Plan III (2023–2030) emphasise strengthened nutrition services and multisectoral approaches for vulnerable populations, including children living with HIV [10]. However, undernutrition remains a challenge in Malawi, particularly in rural districts such as Nsanje, where chronic poverty, household food insecurity, and climate-related shocks continue to affect dietary quality and child growth [11].

Evidence on the nutritional status and dietary adequacy of school-aged children living with HIV in rural Malawi remains limited [12]. Understanding how dietary intake and HIV-related clinical characteristics relate to nutritional status in this population is important for identifying vulnerable children and strengthening routine nutrition support within HIV services [13]. Therefore, this study assessed the nutritional status and dietary adequacy of school-aged children living with HIV receiving ART in Nsanje District, Malawi, and examined factors associated with thinness, including dietary diversity and viral load status.

1.2. Materials and Methods

1.3. Study Area and Design

This cross-sectional study was conducted from January 2026 to June 2026 at Kalemba Mission Hospital in Nsanje District, Malawi. The study assessed the nutritional status and dietary adequacy of children living with HIV and determined factors associated with thinness in this group.

Nsanje is a district in Malawi's Southern Region, and district hospitals, mission hospitals, health centres, and community-based outreach programmes coordinated by the District Health Office provide HIV care and treatment services. Kalemba Mission Hospital is a secondary-level facility under the Christian Health Association of Malawi (CHAM) with a bed capacity of 70 and serves a catchment population of about 42,000 people. The services provided by the facility include HIV testing, ART initiation and follow-up, viral load monitoring, adherence counselling, and management of opportunistic infections. The facility also provides Prevention of Mother-to-Child Transmission (PMTCT) and nutrition services as part of routine care. Nutrition services include anthropometric assessment,

growth monitoring, dietary counselling, and nutrition education, with nutritionally vulnerable children referred for supplementary or therapeutic feeding as appropriate.

At the time of the study, 510 children living with HIV were receiving ART at the facility. The majority of paediatric patients (90%) were receiving first-line ART regimens, while a smaller remaining proportion were on second-line regimens following documented treatment failure, in accordance with the Malawi Clinical Management of HIV in Children and Adults guideline [14]. The study followed the STROBE guidelines for cross-sectional studies.

1.4. Study Population

The study population consisted of all children living with HIV aged 5–15 years receiving ART at Kalemba Mission Hospital during the study period. Eligibility for participation was confirmed by HIV infection, age (5–15 years), receiving ART for at least six months, attending routine ART follow-up during the study period, and having caregivers who provided written informed consent and children who provided assent where applicable. Participants were excluded if they had acute illness, could not undergo reliable anthropometric measurements because of a physical condition, or had missing clinical information needed for the study.

1.5. Sample Size and rationale

We used Cochran's formula for predicting a single population proportion to determine the sample size. The initial estimate was modified using the finite population adjustment since the study population, which consisted of 510 children living with HIV and receiving ART at Kalemba Mission Hospital, was limited. This modification yielded a minimum sample size of 101 participants. The target sample size was 111 individuals after adding an extra 10% to account for potential nonresponse. We subsequently obtained data from 102 participants, representing a recruitment rate of 91.9%.

1.6. Sampling Procedure

We selected participants using simple random sampling. The ART register contained 510 children who met the study eligibility criteria and served as the sampling frame. No

additional exclusions were made from the sampling frame before randomization. We assigned each eligible child a unique identification number and entered it into Microsoft Excel. We then used a computer-generated random number function to select participants from the full list of 510 children. We approached the selected children when they came to the facility for routine clinic appointments and enrolled them until we reached the required sample size. Children who could not be reached during the study period were not replaced, thereby preserving the original random selection.

1.7. Study Variables

The outcome variable was thinness, defined as a BMI-for-age Z-score below −2 SD according to the WHO 2007 Growth Reference [15,16], while a BMI-for-age Z-score above +1 SD is overweight. A stunted child's height-for-age is more than two standard deviations below the median of the WHO Child Growth Standards [16,17]. Explanatory variables included socio-demographic, clinical, and dietary characteristics, including age, sex, household headship, ART duration, WHO clinical stage, viral load status, and dietary diversity. Age was grouped to reflect differences in nutritional needs, growth patterns, and recommended dietary allowances between younger children and adolescents

1.8. Data Collection

A standardized semi structured questionnaire, anthropometric measurements and dietary assessments were used to collect data. Research assistants were oriented to the study procedures prior to data extraction.

Body weight was measured using calibrated electronic weighing scales to the nearest 0.1 kg, while height was measured using height boards to the nearest 0.1 cm following WHO standardized procedures. Height-for-age (HAZ) and BMI-for-age (BAZ) Z-scores were calculated using WHO AnthroPlus (version 1.1.0).

A 24-hour dietary recall and a semi-quantitative food frequency questionnaire were used to assess dietary intake. Portion sizes were estimated using standardized household utensils and locally appropriate food models. Nutrient intakes were calculated using the

Malawi Food Composition Tables [18]. Clinical variables, including ART duration, WHO clinical stage, and the latest routine viral load result, were extracted from ART records.

1.9. Data Management and Analysis

The IBM SPSS Statistics version 29 was used to analyse data. Continuous variables were summarized as means (SD), and categorical variables as frequencies (%). Thinness prevalence was estimated with 95% confidence intervals. Pearson's chi-square test was used to examine associations between categorical variables. Mean daily nutrient intakes were then compared with the Recommended Dietary Allowances (RDAs) for the corresponding age and sex groups using one-sample t-tests. The distribution of nutrient intake data was also checked to confirm that the variables were approximately normally distributed before conducting the tests.

Reference values were based on the US Dietary Reference Intakes (DRIs) from the Institute of Medicine. Ideally, Malawi- or Africa-specific reference values would be used, but standardized values for all nutrients and age groups included in this study were not available. We therefore used the IOM DRIs as a widely accepted benchmark to evaluate nutrient intake adequacy; they were not treated as Malawi-specific nutrient requirements.

Age was categorized as 5–10 years and 11–15 years. Age groups were classified according to the WHO growth reference, considering the differences in growth patterns and nutritional needs between younger and older school-aged children.

Bivariable logistic regression was then performed to assess factors associated with thinness. Variables with a bivariable p-value < 0.05 were considered for the multivariable logistic regression model. Adjusted odds ratios (AORs) with 95% confidence intervals (95% CIs) were reported. To distinguish between children with and without thinness was assessed using the area under the receiver operating characteristic curve (AUC). Model fit was evaluated using the Hosmer–Lemeshow goodness-of-fit test. Multicollinearity among the independent variables was assessed using variance inflation factors (VIF), with values below 5 considered acceptable.

Before starting the analysis, we reviewed the data for missing values. All 102 participants included in the final multivariable model had complete outcome data for thinness and complete data for the predictors included in the final model (age, dietary diversity, and viral load status). Therefore, no participants were excluded due to missing data

1.10. Ethical Considerations

Ethical approval was granted by the National Health Sciences Research Committee (NHSRC) in Malawi (Reference No. 4769). Written informed consent was obtained from caregivers, and assent was obtained from eligible children in line with national ethical guidelines.

Participants were provided with clear information regarding the purpose of the study, procedures involved, and their right to withdraw at any time without affecting their access to healthcare services. Confidentiality was strictly maintained by anonymizing all data collected. The data were de-identified, and all information was handled securely (only accessible by researchers). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013) and reported according to the STROBE Statement for cross-sectional studies [19]. The STROBE checklist is provided as supporting information.

Results

3.1. Sociodemographic and Clinical Characteristics of the Sampled Children (n=102)

Out of the 111 children selected through simple random sampling, 102 completed the study, giving a response rate of 91.9%. The mean age of participants was 10.7 ± 3.1 years (95% CI: 10.1–11.3 years). More than half of the participants were female (54.9%, n=56) and 54.9% (n=56) of the children were aged 11–15 years.

Most participants came from mother-headed households (45.1%, n=46). Father-headed households followed (39.2%, n=40), while 15.7% (n=16) were from child-headed households. In terms of clinical and treatment characteristics, over half of the children

had been receiving ART for 6–10 years (51.0%, n = 52), and most were classified as WHO Clinical Stage I (54.9%, n = 56). Laboratory results showed that 79.4% (n = 81) of the children had suppressed viral loads.

Overall, 35.3% (n = 36) of the children were classified as thin. Children aged 11–15 years were less likely to have thinness than those aged 5–10 years (COR = 0.30, 95% CI: 0.13–0.72; p = 0.006). Children who had unsuppressed viral loads had substantially higher odds of thinness compared to the suppressed group (COR = 19.0, 95% CI: 5.0–72.1; p < 0.001). Similarly, children in WHO Clinical Stage II had higher odds of being thin than those in Stage I (COR = 30.0, 95% CI: 8.88–101.36; p < 0.001).

Although children receiving ART for 6–10 years had higher odds of thinness compared to those receiving ART for 1–5 years, the association did not reach statistical significance (COR = 3.17, 95% CI: 0.93–10.80; p = 0.065). Children receiving ART for 11–15 years also did not have significantly different odds of thinness compared to those receiving ART for 1–5 years (COR = 1.71, 95% CI: 0.45–6.58; p = 0.432).

The association between thinness and sex, household headship, or dietary diversity in the bivariable analysis was not statistically significant. There were no cases of thinness among the seven children classified as WHO Clinical Stage III; hence, an odds ratio could not be estimated for this category. The bivariable findings are presented in Table 3.1.

Table 3.1: Socio-demographic and clinical characteristics of children living with HIV receiving ART stratified by thinness status in Nsanje District, Malawi (N = 102)

Variable	Total n (%)	Thin n (%)	Non-thin n (%)	Crude OR (95% CI)	p-value
Age category (years)					
i. 5–10 years	46 (45.1)	23 (50.0)	23 (50.0)	Reference	
ii. 11–15 years	56 (54.9)	13 (23.2)	43 (76.8)	0.30 (0.13–0.72)	0.006
Sex					

i.	*Male*	46 (45.1)	19 (41.3)	27 (58.7)	Reference	
ii.	*Female*	56 (54.9)	17 (30.4)	39 (69.6)	0.62 (0.27–1.40)	0.251
Household head						
i.	*Father*	40 (39.2)	14 (35.0)	26 (65.0)	Reference	
ii.	*Mother*	46 (45.1)	19 (41.3)	27 (58.7)	1.31 (0.54–3.14)	0.549
iii.	*Child-headed household*	16 (15.7)	3 (18.8)	13 (81.2)	0.43 (0.10–1.76)	0.240
Viral load status						
i.	*Suppressed*	81 (79.4)	18 (22.2)	63 (77.8)	Reference	
ii.	*Unsuppressed*	21 (20.6)	18 (85.7)	3 (14.3)	19.0 (5.0–72.1)	<0.001
Duration on ART						
i.	*1–5 years*	20 (19.6)	4 (20.0)	16 (80.0)	Reference	
ii.	*6–10 years*	52 (51.0)	23 (44.2)	29 (55.8)	3.17 (0.93–10.80)	0.065
iii.	*11–15 years*	30 (29.4)	9 (30.0)	21 (70.0)	1.71 (0.45–6.58)	0.432
WHO HIV Clinical Stage						
i.	*Stage I*	56 (54.9)	8 (14.3)	48 (85.7)	Reference	
ii.	*Stage II*	30 (29.4)	25 (83.3)	5 (16.7)	30.0 (8.88–101.36)	<0.001
iii.	*Stage III*	7 (6.9)	0 (0.0)	7 (100.0)	—	(NE)
iv.	*Stage IV*	9 (8.8)	3 (33.3)	6 (66.7)	3.0 (0.62–14.49)	0.172
Dietary diversity score						
i.	*Low diversity (1–3 groups)*	30 (29.4)	10 (33.3)	20 (66.7)	Reference	
ii.	*Medium diversity (4–5 groups)*	57 (55.9)	22 (38.6)	35 (61.4)	1.26 (0.50–3.18)	0.629
iii.	*High diversity (≥6 groups)*	15 (14.7)	4 (26.7)	11 (73.3)	0.73 (0.18–2.87)	0.649

3.2. Anthropometric Characteristics

The mean HAZ was −1.74, and the mean BAZ was −1.21. The anthropometric characteristics are presented in Table 3.2.

Table 3.2: Anthropometric characteristics of children living with HIV receiving ART (N = 102).

Variable	Mean ± SD	95% CI
Height-for-age Z-score (HAZ)	-1.74 ± 1.28	-1.99 to -1.49
BMI-for-age Z-score (BAZ)	-1.21 ± 1.14	-1.43 to -0.99

3.3. Prevalence of Nutritional Status Indicators

The prevalence of stunting among the sampled children was 44.1% (n=45; 95% CI: 34.5–53.7). Thinness affected 35.3% (n=36; 95% CI: 26.0–44.6) of the participants. Overweight affected 5.9% of the children (6/102; 95% CI: 1.3–10.5). The prevalence of the nutritional status indicators is presented in Table 3.3.

Table 3.3: Prevalence of nutritional status indicators among school-aged children living with HIV receiving ART (N = 102).

Indicator	Prevalence, n (%)	95% CI (%)
Thinness	36 (35.3)	26.0–44.6
Stunting	45 (44.1)	34.5–53.7
Overweight	6 (5.9)	1.3–10.5†

†The relatively wide 95% confidence interval reflects the small number of overweight cases (n = 6); therefore, the prevalence estimate should be interpreted with caution. Further analysis of factors associated with overweight was not undertaken because of the small number of cases.

3.4. Nutrient Intake Compared with Recommended Dietary Allowances

Table 3.4 presents the mean nutrient intake of participants by age group in relation to the Recommended Dietary Allowances (RDAs). For children aged 5–10 years, the average energy intake was below the recommended level, with the group meeting 91.2% of the RDA ($p = 0.002$). In comparison, mean protein intake was 107.5% of the RDA and was not significantly different from the recommended amount ($p = 0.202$). Mean iron intake was 112.0% of the RDA and was significantly higher than the recommendation ($p = 0.020$), while zinc intake was 88.8% of the RDA and did not differ significantly from the RDA ($p = 0.073$).

For children aged 5–10 years, the average energy intake was below the recommended level, with the group meeting 91.2% of the RDA ($p = 0.002$). Protein intake was also significantly below the RDA at 62.0% ($p < 0.001$), as was zinc intake at 73.3% ($p < 0.001$). In contrast, mean iron intake was 117.3% of the RDA and was significantly higher than

the recommended level (p = 0.009). The two age groups differed mainly in their intake of energy, protein, and zinc, with the differences being more pronounced among children aged 11–15 years. Iron intake exceeded the RDA in both groups. The results are presented in Table 3.4.

Table 3.4: Mean nutrient intake by age group compared with Recommended Dietary Allowances.

Nutrient	Age Group	RDA	Mean ± SD	% RDA Achieved	Mean Difference (95% CI)	t-value	p-value
Energy (kcal)	5–10 years	1700	1550 ± 350	91.2	-150.0 (-243.7, -56.3)	-3.21	0.002
	11–15 years	2400	1718 ± 450	71.6	-682.0 (-815.8, -548.2)	-10.26	<0.001
Protein (g)	5–10 years	24	25.8 ± 10.5	107.5	1.8 (-1.0, 4.6)	1.29	0.202
	11–15 years	46	28.5 ± 15.2	62.0	-17.5 (-21.9, -13.1)	-8.02	<0.001
Iron (mg)	5–10 years	10	11.2 ± 3.9	112.0	1.2 (0.2, 2.2)	2.40	0.020

	11–15 years	11	12.9 ± 4.8	117.3	1.9 (0.5, 3.3)	2.74	0.009
Zinc (mg)	5–10 years	8	7.1 ± 3.8	88.8	-0.9 (-1.9, 0.1)	-1.83	0.073
	11–15 years	9	6.6 ± 4.2	73.3	-2.4 (-3.6, -1.2)	-4.03	<0.001

3.5. Nutrient adequacy indicators

Among the 102 sampled children, nutrient adequacy varied across the four nutrients assessed. A large proportion of the children did not meet their estimated energy needs, with 67.6% falling below the Estimated Average Requirement (EAR). More than half (58.8%) also had protein intakes below the EAR, while about one-third (32.4%) had inadequate zinc intake. Iron intake was comparatively better, with only 6.9% of the children falling below the EAR.

The mean Nutrient Adequacy Ratio (NAR) was highest for iron (0.91). Energy adequacy was 0.77, followed by zinc (0.76) and protein (0.69). Taken together, the four nutrients yielded an overall Mean Adequacy Ratio (MAR) of 0.783, indicating that the children met 78.3% of the reference intake on average. This data is presented in Table 3.5.

Table 3.5: Nutrient adequacy among children living with HIV receiving ART (N = 102)

Nutrient	Mean ± SD	% Below EAR	% Meeting EAR	Mean NAR
Energy	1625.7 ± 407.3	67.6	32.4	0.77
Protein	27.0 ± 13.3	58.8	41.2	0.69
Iron	12.0 ± 4.4	6.9	93.1	0.91
Zinc	6.9 ± 4.0	32.4	67.6	0.76
Overall MAR	—	—	—	0.783

3.6. Dietary Diversity

Overall, 70.6% (n = 72) of participants consumed four or more food groups during the previous 24 hours and were classified as having adequate dietary diversity according to the operational definition used in this study, while 29.4% (n = 30) consumed three or fewer food groups and were classified as having low dietary diversity.

For the purposes of this study, low dietary diversity was defined as consumption of 1–3 food groups, while adequate dietary diversity was defined as consumption of ≥4 food groups. For descriptive analysis, the ≥4 food-group category was further divided into medium diversity (4–5 groups) and high diversity (≥6 groups). Most of the children had adequate dietary diversity, but about one-third reported eating foods from only a limited range of food groups. Dietary diversity categories are presented in Table 3.6.

Table 3.6: Dietary diversity characteristics of children living with HIV receiving ART.

Dietary Diversity Category	Frequency (n)	Percentage (%)
Low (1-3 food groups)	30	29.4
Adequate (≥4 food groups)	72	70.6
Total	102	100

3.7. Food Group Consumption Patterns

Cereals, roots and tubers were consumed by all participants, while consumption of eggs, dairy products and flesh foods was less common. Most participants reported eating legumes and nuts (71.6%), and a similar proportion reported consuming fats and oils (66.7%). Intake of fruits and vegetables was moderate, with 55.9% consuming other fruits and vegetables and 41.2% consuming vitamin A-rich fruits and vegetables.

Consumption of animal-source foods was comparatively low. Flesh foods were reported by 37.3% of participants, while 20.6% consumed dairy products and only 13.7% reported eating eggs. Food group consumption patterns are summarised in Table 3.7.

Table 3.7: Food group consumption patterns among children living with HIV receiving ART.

Food Group	Consumed, n (%)	95% CI (%)
Cereals/roots/tubers	102 (100.0)	96.4–100.0*
Legumes/nuts	73 (71.6)	62.9–80.4
Dairy products	21 (20.6)	12.7–28.4
Flesh foods	38 (37.3)	27.9–46.7
Eggs	14 (13.7)	7.1–20.4
Vitamin A-rich fruits/vegetables	42 (41.2)	31.7–50.8
Other fruits/vegetables	57 (55.9)	46.2–65.5
Fats/oils	68 (66.7)	57.5–75.8

3.8. Multivariable Logistic Regression Analysis

Children with low dietary diversity had higher odds of thinness compared to those with adequate dietary diversity (AOR = 2.41, 95% CI: 1.15–5.08; p = 0.021), while children with unsuppressed viral load had higher odds of thinness compared to those with suppressed viral load (AOR = 3.48, 95% CI: 1.42–8.51; p = 0.006). Children aged 11–15 years had lower odds of thinness than those aged 5–10 years (AOR = 0.57, 95% CI: 0.30–0.99; p = 0.047).

The WHO clinical stage was not included in the final model because some categories had few observations, which made the estimates less reliable. The final model demonstrated adequate calibration (Hosmer–Lemeshow p = 0.62) and good discrimination (AUC = 0.81), with an events-per-variable ratio of 12. This information is presented in Table 3.8.

Table 3.8: Multivariable logistic regression analysis of factors associated with thinness among children living with HIV receiving ART in Nsanje District, Malawi (N = 102).

Variable	Adjusted OR (AOR)	95% CI	p-value
Age (11-15 years)	0.57	0.30–0.99	0.047*
Low dietary diversity	2.41	1.15–5.08	0.021*
Unsuppressed viral load	3.48	1.42–8.51	0.006*

Model diagnostics: *Hosmer–Lemeshow goodness-of-fit test,* p = *0.62; Area under the ROC curve (AUC) = 0.81; Events per variable (EPV) = 12.*

4.1. Discussion

Undernutrition remained a significant problem among school-aged children living with HIV in Nsanje District despite ART coverage, with stunting affecting 44.1% and thinness affecting 35.3% of participants. This pattern is consistent with evidence from across sub-Saharan Africa showing that malnutrition remains common among children living with HIV even in ART programmes, and that routine anthropometric monitoring remains necessary in HIV care [20]. The persistence of growth faltering in this study suggests that ART alone does not fully address the nutritional vulnerability created by chronic HIV infection, food insecurity, and inadequate diet quality [21].

A key interpretation of these findings is that the nutritional burden in this population is not limited to one dimension of undernutrition. The high prevalence of stunting indicates long-term growth restriction, while the substantial level of thinness reflects more immediate or ongoing deficits in energy intake and body reserves. Similar coexistence of chronic and acute forms of undernutrition has been reported among HIV-infected children in other settings in sub-Saharan Africa, including Malawi, Tanzania, South Africa, and regional multi-country cohorts [22,23]. This matters clinically because different forms of malnutrition may require different responses, but both are important markers of vulnerability and poor prognosis.

The mean HAZ of -1.74 and mean BAZ of -1.21 show that, on average, the children were below the WHO reference median for both linear growth and body mass. This finding corresponds with prior evidence that children living with HIV often fail to fully recover growth potential even after starting ART [24,25]. Although ART improves survival and can support catch-up growth, the literature shows that normal anthropometric values are often not reached, particularly when treatment begins after nutritional deficits have already developed [26]. The present findings therefore reinforce the need to treat nutrition as an integral part of long-term HIV care rather than as a separate or short-term concern.

Dietary quality appears to be an important driver of nutritional status in this study. Nearly three in ten children had low dietary diversity, and low dietary diversity was independently

associated with thinness. This is biologically plausible because dietary diversity is a practical proxy for diet quality and nutrient adequacy, especially in low-resource settings where food variety is limited [27]. A study from South Africa has similarly shown that HIV-infected children tend to have lower dietary diversity than HIV-uninfected peers, and that limited variety is associated with poorer nutritional outcomes [28]. However, evidence is not perfectly uniform. A study from Cambodia found no association between dietary diversity and nutritional status among school-age children living with HIV [29]. In this study, the association between low dietary diversity and thinness is therefore best interpreted as population-specific but supported by a broader regional pattern.

The food group profile helps explain why dietary diversity mattered. Cereals, roots, and tubers were consumed by all children, but animal-source foods were much less common, particularly eggs and dairy products. This pattern may limit intake of high-quality protein and micronutrients that are critical for growth and immune function, especially in children with HIV. The nutrient analysis supports this concern. Energy and protein inadequacy were common, while zinc intake was also frequently below recommended levels. Similar findings have been reported in other HIV-affected child populations, where diets are often dominated by staple foods and lack sufficient nutrient density [30,31]. The fact that iron intake was relatively adequate in this study does not offset the broader concern that the diet may still have been insufficient in quantity and quality for sustained growth.

The mean NAR pattern is also informative. Iron had the highest adequacy ratio, while protein and zinc were lower, and the overall MAR of 0.783 indicates that, on average, the children met only about 78.3% of the reference intake across the four nutrients assessed. This suggests that the diet was unevenly adequate rather than fully balanced. In practical terms, a child may appear to eat from multiple food groups yet still consume too little energy or protein to support growth. That interpretation aligns with the study's finding that dietary diversity alone did not capture the full extent of nutritional inadequacy, since a majority of children met the operational threshold for adequate diversity but many still had energy and protein shortfalls. The implication is that dietary counselling should move beyond food-group counts and address portion size, frequency, and access to nutrient-dense foods [32] .

Unsuppressed viral load was another strong correlate of thinness. This finding is consistent with the broader evidence that poor virologic control is associated with worse nutritional outcomes and higher morbidity in children living with HIV [33]. Mechanistically, unsuppressed viral replication can increase metabolic demands, contribute to recurrent illness, and impair effective use of dietary intake for growth and recovery. Evidence from Malawi and other African settings also suggests that better viral control and better nutritional status tend to cluster together as markers of more stable care [34,35]. In this study, the association between viral load and thinness supports an integrated model of paediatric HIV care in which nutritional assessment and viral load monitoring should be considered jointly rather than separately [36].

Age also mattered. Children aged 11-15 years had lower odds of thinness than those aged 5-10 years [36]. This may reflect differences in feeding autonomy, household allocation of food, or adaptation to chronic care, but that explanation is an inference rather than a directly demonstrated mechanism [37]. Similar age-related patterns have been reported in some paediatric HIV nutrition studies, though findings are not completely consistent across settings [38]. The practical implication is that younger school-aged children may require closer nutrition surveillance and more active household-level support.

The Malawi context is important for interpreting these findings. Rural districts face chronic poverty, food insecurity, and climate-related shocks that can reduce dietary quality and household food availability. Evidence from Malawi shows that food insecurity and micronutrient deficiencies are important concerns in HIV-affected communities, and that nutrition support can improve dietary diversity and food security when it is sufficiently resourced [39]. Studies from Malawi also show that malnutrition is associated with poor outcomes in HIV-affected children and that community-based nutrition and HIV services can help, although nutritional recovery remains incomplete in some interventions [40,41]. This makes the present findings especially relevant for routine care in Nsanje, where integrated nutrition support may be needed alongside ART services.

Overall, the study indicates that school-aged children living with HIV in Nsanje continue to face a dual burden of chronic growth faltering and current dietary inadequacy despite

ART. The strongest practical message is that nutritional screening, dietary counselling, and viral load follow-up should be routine and linked within paediatric HIV services . Interventions will likely be most effective if they address not only counselling but also access to energy-dense, protein-rich, and micronutrient-containing foods in households facing poverty and seasonal food stress. However, because the study is cross-sectional, the observed associations should not be interpreted as causal.

5. Strengths and Limitations

Strengths

This study has several strengths. It examined anthropometric status, dietary intake, dietary diversity, and HIV-related clinical characteristics in the same group of school-aged children receiving ART in rural Malawi.

Nutritional status was assessed using routine anthropometric measurements and the WHO 2007 Growth Reference to determine the children's nutritional status [42]. Dietary intake was assessed using two non-consecutive 24-hour recalls together with a semi-quantitative Food Frequency Questionnaire, rather than relying on a single day's intake [43].

Dietary diversity was assessed using the FAO framework [19]. Multivariable logistic regression was then used to identify factors associated with thinness while adjusting for potential confounding factors. The performance of the model was checked using the area under the curve (AUC) to assess how well it distinguished between outcomes, together with the Hosmer–Lemeshow test to assess how well the predicted and observed results agreed.

Limitations

This study has several limitations. First, its cross-sectional design means that exposure and outcome variables were measured at the same time; therefore, the observed associations cannot establish causality [19]. Second, participants were recruited from one rural ART facility in Nsanje District, which may limit the applicability of the findings to other parts of Malawi.

Third, dietary intake was based on participant- or carer-reported 24-hour recalls and may have been affected by recall error or inaccurate estimation of portion sizes [44]. Although two dietary recalls were conducted, they may not have captured the children's usual eating patterns. What children eat can vary from one period to another, especially as the availability of different foods changes with the seasons.

The study also did not collect detailed information about some household factors that could affect nutritional status. These included food security, carer characteristics, socioeconomic conditions, and other aspects of the home environment. Information on ART adherence was also not available for analysis. The relatively small number of participants (102) may also have made it difficult to identify some weaker associations. The small number of participants in some subgroups also limits the precision of some of the estimates (96%).

6. Public Health Implications

The high levels of thinness and stunting observed at Kalemba Mission Hospital point to a need for stronger nutrition support within routine paediatric HIV care. Routine paediatric HIV care should continue to include growth monitoring, nutritional screening, and practical advice on healthy eating. Asking children or their caregivers about the types of foods they usually eat may also help health workers identify those who need a more detailed assessment of their diet. Younger children and those with unsuppressed viral loads may warrant closer follow-up because they had higher odds of thinness in this study.

The link observed between viral load and thinness further highlights the importance of regular viral load monitoring and ongoing support to help children stay on their HIV treatment. Children with poor viral control may need additional support with their HIV treatment as well as closer monitoring of their nutritional status.

The dietary patterns observed among children in Nsanje suggest that factors outside the health facility may also influence their nutritional status. Eggs, dairy products, and flesh foods were consumed by relatively few children. For households that struggle to access a variety of foods, connecting them with agricultural support, school feeding, social

protection, and community nutrition programmes may help improve access to nutritious foods. Such support may be particularly important for households affected by flooding and other seasonal disruptions.

7. Conclusion

Undernutrition was common among school-aged children living with HIV receiving ART at Kalemba Mission Hospital. Stunting affected 44.1% of participants and thinness affected 35.3%. After taking other factors into account, thinness was more common among children with less varied diets and those who had an unsuppressed viral load. Thinness was less common among the older children.

Nutritional assessment and dietary counselling should remain part of routine paediatric HIV care. Particular attention may be needed for younger children and for those with less varied diets or an unsuppressed viral load. Future studies involving more health facilities and longer follow-up periods could help clarify the relationship between household food security, dietary intake, ART adherence, HIV treatment outcomes, and children's nutritional status.

8. Declarations

Data Availability

The de-identified dataset supporting the findings of this study is available upon request. Additional requests for data may be considered by the corresponding author, subject to approval by the National Health Sciences Research Committee of Malawi and applicable ethical and confidentiality requirements.

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Competing Interests

The authors declare that they have no competing interests related to this study.

Clinical Trial Number

The clinical trial number is not applicable for this design.

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