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# Undernutrition and Associated Factors Among Children and Adolescents Aged 2 to 19 Years Under Antiretroviral Therapy at the Bamenda Regional Hospital, Cameroon

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**Abstract:** Poor nutrition aggravates the effect of HIV by further decreasing the immune system and potentially reducing the efficacy of antiretroviral therapy (ART). This study aimed to assess associated factors of undernutrition among children and adolescents aged 2-19 years old at the paediatric daycare center of the Bamenda Regional Hospital, North-West region of Cameroon. This analytical cross-sectional study included 31 children and 170 adolescents for which anthropometric, biochemical, clinical and dietary parameters were assessed. Knowledge, feeding practices, hygiene and sanitation of parents/guardians were also assessed using a structured pretested questionnaire. The results showed that the prevalence of undernutrition, stunting, acute malnutrition and underweight among study population were 32.8%, 27.4%, 20.4% and 13.9%, respectively. Age between 2 to 9 years old (aOR = 3.988; p = 0.018), occurrence of typhoid fever (aOR = 7.250; p = 0.039), and avitaminosis A (aOR = 7.664; p = 0.004) were positively associated with undernutrition. Being a female (aOR = 0.378; p = 0.029) was negatively associated with undernutrition. Age (p = 0.012), high levels of LDL-cholesterol (p = 0.015) and low dairy products' intake (p = 0.048) were associated with underweight. Avitaminosis A (p = 0.030) and hyperalbuminemia (p = 0.014) were positively associated with stunting. Positively-associated factors of acute malnutrition were age (p = 0.013), avitaminosis A (p = 0.005), and hypertriglyceridemia (p = 0.039). Out of the 8 food groups recorded, pulses and dairy products were infrequently consumed. About one-quarter of households had good knowledge of a balanced diet. Dyslipidemia was predominant (56.2%). Summarily, the prevalence of undernutrition and its forms were high among HIV-positive children and adolescents. Associated factors were being a male, being a child aged 2 to 9 years, occurrence of typhoid fever, avitaminosis A, hyperalbuminemia and dyslipidemia.

**Keywords:** Associated Factors, Dietary Habits, Dyslipidemia, HIV-Positive Children and Adolescents, Undernutrition

## 1. Introduction

Good nutritional status is fundamental to the optimal outcome of effective antiviral therapy (ART) among children and adolescents. The nutritional status of children and adolescents can be affected by several illnesses and diseases including HIV/AIDS infection. Human Immunodeficiency Virus (HIV) remains one of the biggest threats to global health and people living with HIV including children and adolescents which are vulnerable to various health-related issues [1]. HIV-infected children are at risk of having a poor nutritional status due to poor or inadequate intake of

nutrients, nutrient loss due to malabsorption, metabolic alterations and drug-nutrient interactions [2].

The relationship between nutrition and HIV is a vicious cycle, similar to the relationship between nutrition and other infections. HIV compromises nutritional status, and poor nutrition further weakens the immune system, increasing susceptibility to opportunistic infections (OIs) [3]. HIV infection progressively destroys the immune system, leading to recurrent OIs, debilitation, and death. Poor nutritional status is one of the major complications of HIV and a significant factor in full-blown AIDS. HIV can cause or worsen undernutrition by causing reduced food intake, increased energy requirements, and poor nutrient absorption [4, 5]. Malnutrition, especially undernutrition in turns further weakens the immune system, increasing vulnerability to infection and worsening the disease's impact [6]. This cycle can result in the following, weight loss, the most common and often most disturbing symptom of HIV reported in most people with AIDS, loss of muscle tissue and fat, vitamin and mineral deficiencies, increased nutritional needs because of infections, metabolic changes, viral replication and poor nutrient absorption, weakness, reduced productivity and immune function and increased susceptibility to OIs [4, 6].

HIV positive children and adolescents have known increased nutrient needs to maintain adequate nutritional status. The focus of nutrition interventions has moved over the past two decades, from simply supporting the patient to ensuring that the treated children are well nourished, since they have the additional nutritional demands of growth and development [7]. Nutrition is not only an adjunct therapy but potentially a primary therapy in locations with limited access to antivirals [8]. The advancement of antiretroviral therapy use in the management of HIV infection has brought about a drastic increase in life expectancy of children and adolescents living with HIV and AIDS [9, 10]. However, the therapy is commonly accompanied with adverse effects (nausea, diarrhoea, fat redistribution, pancreatitis, lactic acidosis, lipid abnormalities, and hyperglycemia) that may be detrimental to child nutritional status [11]. Medication alongside proper nutrition is a major component of maintaining good health and quality of life for children and adolescents living with HIV/AIDS.

Cameroon is among the central African countries most affected by HIV/AIDS. The prevalence rate is estimated at 4.3%, and women and children are the most vulnerable groups [12]. Also, the statistics gotten from the Regional Hospital in Bamenda indicated that the number of children and adolescents receiving treatment has increased from 303 in 2018 to 400 children in 2020. The socio-political crisis affecting the North-West and South-West Regions of Cameroon, has led to some food insecurity issues due to limited farming activities in the villages, road blockages and insecurity preventing food supply of foods in Bamenda city. It is therefore crucial to better apprehend the nutritional status of the sensitive and vulnerable group which are HIV-positive children and adolescents. Such an assessment may constitute scientific basis for proposition of appropriate guides for the management of health conditions of HIV-positive children and adolescents. This study thus aimed at assessing the nutritional status of children and adolescents aged 2-19 years under antiretroviral treatment at Bamenda regional hospital, North West region of Cameroon.

# 2. Materials and Methods

### *2.1. Study Design*

A hospital-based cross-sectional study was carried out. This design was used because it provides a clear snapshot of the frequency and characteristics of the study population within a given period.

### *2.2. Ethical Considerations*

The authorization to carry out the study was granted by the Cameroon Ministry of Public Health (reference number: 014/APP/RDPH/RHS/IRB) and the ethical approval was obtained from the Ethical Committee Review Board of the Regional Hospital of Bamenda (reference number: 38/ATT/NWR/RDPH). Before data collection, written informed consent was obtained from the parents/guardians of the children. To ensure confidentiality, identification codes (instead of names) were used on the questionnaire and the investigator ensured that the information provided was only used strictly for research purpose.

### *2.3. Study Setting*

The North-West Region is found in the Western highlands of Cameroon. It is bordered to the Southwest by the South-West Region, to the West by the West Region, to the East by the Adamawa Region and to the North by the federal republic of Nigeria. It has a population of about 1,728,953 inhabitants, with Bamenda as its capital city. The Bamenda Regional Hospital is one of the referral hospitals of the North-West Region of Cameroon, and is located in Bamenda town. The study was carried out at the paediatric daycare Centre in the Bamenda Regional Hospital. At that paediatric daycare HIV positive children and adolescents are managed medically considering their drug dispensation, nutritional counselling and routine checkups [13].

### *2.4. Research Instruments, Chemicals, Reagents and Kits*

Quantification of haemoglobin in blood was done with the aid of a haemoglobinometer (Hemocue Hb 301 meter). It has its characteristics as such, dimension of 150mm x 70mm x 160mm, power DC6V (two CR2032 Batteries) gives results within 10 seconds, uses capillary or venous blood (5~10μl) and it has a measuring range of 4.0g/dl~24.0g/dl. The commercial kits of total cholesterol, triglycerides, HDL, and albumin from RANDOX Laboratories Ltd were used in this study.

### *2.5. Sampling Procedure*

The population sample size was determined using the

Yamane's formula. Taking in consideration a population size of 400 HIV-infected children and a margin of error of 5%, the study sample size was estimated at 200 participants. A convenience sampling approach was used to recruit participants.

The participants in the study were HIV/AIDS-positive children and adolescents aged 2 to 19 years old who were receiving antiretroviral treatment at the Bamenda Regional Hospital. Their mothers/caregivers served as the respondents. These children and adolescents were under antiretroviral treatment for at least a year.

HIV-infected participants below 2 years and above 19 years of age on ART, those recently diagnosed and registered, patients or mothers/caregivers who refused to sign the participant's consent form and those whose questionnaires were not completed were not considered for the study.

### *2.6. Administration of Questionnaires*

A structured questionnaire was developed on different aspect of assessing socio-demographic characteristics, anthropometric data, clinical signs, feeding habits, lifestyles and the HIV regimen of the participants. The questionnaire was pre-tested to help us determine if respondents clearly understood the questions. Questionnaires data were collected during clinical visit of patients to the hospital, by face-to-face interview. This was done by a self-presentation to the patient/caregiver either in *Pidgin* (local language used by the community), English or French language, depending on the language which was best understood by the participant.

### *2.7. Anthropometric Measurements*

The age of the children was obtained from their hospital files, and their anthropometric data was collected using standard procedures as stipulated in the guidelines [14]. The weight of each participant was measured in kilograms using Salter scale with accuracy of 1Kg, while their height was recorded in centimeters using a stadiometer with a headstand to the nearest 0.1cm. A non-elastic mid-upper arm circumference tape was used to measure the mid-upper arm of the participants (MUAC tape) to the nearest 0.1mm. To define undernutrition, several anthropometric indicators are used according to WHO definitions: height-for-age, weight-for-age and BMI-for-age. We used the 2006 WHO growth charts for children <5 [14], and the 2007 WHO growth charts for children ≥ 5 [15].

### *2.8. Quantification of Biochemical Parameters*

Blood samples of the participants were collected into EDTA and dry tubes and used for the respective biochemical tests. The haemoglobin level was determined using a haemoglobin meter (Hemocue Hb 301 meter) [16].

Albumin levels in blood samples of the participants were quantified according to the manufacturer's instructions. Briefly, to 1 mL of bromocresol was added 5µl of either aqueous albumin or blood serum, then the mixtures were incubated for 5 min at 37°C and the absorbance was read at 505 nm [17].

The serum total cholesterol, HDL-cholesterol, LDL-cholesterol and triglycerides levels were determined following the manufacturer's guidelines. For the total cholesterol, 1 mL of cholesterol reagent was added to 10 µL of serum and then the mixture was incubated at room temperature for 10 min. The absorbance was recorded at 505nm and the cholesterol concentration was calculated accordingly. The serum triglycerides were estimated by adding 1000 µL of enzyme reagent to 10 µL of purified water, the mixture was incubated at room temperature for 15 min, and the absorbance was measured at 505nm. The HDL level of the participants was determined following mixture of 200 µL of serum and 300 µL of precipitating reagent. Thereafter, the mixture was centrifuged (3000 rpm, 10 min) and 1000 µL of the cholesterol reagent were added to the supernatant, and the absorbance was measured at 505 nm. Based on HDL concentrations, LDL levels were calculated using the Friedewald equation (LDL = Total cholesterol - HDL-triglycerides/5).

In accordance with the United States National Cholesterol Education Program, Adult Treatment Panel III (NCEP-ATP III) guidelines, abnormal lipid profile was defined as total cholesterol ≥ 200 mg/dl, HDL-cholesterol< 40 mg/dl, LDL-cholesterol ≥ 130 mg/dl, triglycerides ≥ 150 mg/dl and total cholesterol/HDL-cholesterol ratio ≥ 5 [18].

The number of CD4 cells per cubic millimeter of the participants' blood was measured using a flow cytometer while the viral load was measured using serologic assays.

### *2.9. Clinical, WASH and Dietary Indicators*

Clinical assessment was done by trained health personnel checking for oedema, bitot spots, goiter, hair color and palm color. Water, hygiene and sanitation indicators consisted of investigating the source of drinking water, the source of cooking water and the type of defecating facility used. Lifestyle and dietary habits were more about knowledge of balanced diet, meal frequency per day, periods when meals were taken, lack of appetite, and the intake of dietary supplements. A food frequency intake was recorded using the questionnaire. To this effect the respondents were asked to list out the foods and beverages/snacks their children consumed in the past three days, and probing was done for any food forgotten during the quick list.

### *2.10. Data Analysis*

Weight-for-age, height-for-age and BMI-for-age z-scores were calculated using Web-based WHO AnthroPlus software version 3.2.2. Data on dietary intake, knowledge and feeding practices of mothers/caregivers were entered in Microsoft excel version 2016 and exported to SPSS version 26 for Windows for statistical analysis. Descriptive statistics (frequencies and percentages) were used to describe nominal data. Continuous data presenting a skewed distribution were reported using median and interquartile range. Independent Student t test was performed to compare anthropometric and biochemical parameters between children and adolescents.

Chi-square test was carried out to compare the clinical profile between children and adolescents. Multiple logistic regressions were done to determine the putative factors of undernutrition, wasting, stunting and acute malnutrition in the study population. Significance level was set at <0.05.

# 3. Results

### *3.1. Household Characteristics*

Nearly half of the mothers earned secondary education and were almost all Christian and from Grassfield tribe (table 1). Virtually, 43.3% of mothers were self-employed and the main meal provider of the family. Almost Two-third of the foods were obtained from the market and the rest from the farm.

### *3.2. Child and Adolescent Characteristics*

A total of 109 HIV-infected participants were female and 15.4% were children aged 2 to 9 years old (table 1). The median weight and height of the study population was respectively 45 kg and 149 cm. Of the consented participants, 13.9% were underweight, 27.4% were stunted, 10.0% were acute malnourished based on BMI-for-age and 20.4% were MUAC-based acute malnourished. Overall, the prevalence of undernutrition among the study population was 32.8%. Among children, the prevalence of undernutrition, underweight, stunting and BAZ-based acute malnutrition was 38.7%, 25.8%, 29.0% and 16.1%, respectively. Among adolescents, the prevalence of undernutrition, underweight, stunting and BAZ-based acute malnutrition was 31.8%, 11.8%, 27.1% and 8.8%, respectively. Within boys, children had significantly lower weight-for-age and height-for-age z-scores than adolescents while female children had statistically lower BMI-for-age z-scores compared to adolescents (table 2). Up to 11.0% of the participants were suffering from avitaminosis A, malaria, diarrhoea, typhoid or anemia while about one-quarter had fever and one-fifth had colored palms (Table 1). Regarding clinical signs, colored tongue was more prevalent among children than adolescents (table 2). The most common HIV regimen used by the participants was Efavirenz (22.4%) and less than 7% were on dual therapy (table 1). Half of the population had a lower viral load (< 10000 copies/ml) and were not at risk of developing illnesses or infections (median CD4 cell count above 200 cells/mm) (Table 1). Hemoglobin and albumin levels were in the normal ranges for 87.6% and 89.5% of the study population, respectively. The prevalence of hypercholesterolemia and hypertriglyceridemia represented 16.9% and 4.5%, respectively. However, children had higher total cholesterol and triglyceride levels compared to adolescents (Table 2). Abnormal high levels of LDL- and HDL-cholesterol affected 20.4% and 36.8% of the study population. Coronary heart disease risk, determined by total cholesterol/HDL-cholesterol ratio, was higher among 10.4% of the study population. Overall, the prevalence of dyslipidemia was 56.2% among patients.

***Table 1.*** *Sociodemographic, anthropometric, clinical and biochemical characteristics of the study population (n= 201).*

| Maternal characteristics | Statistics | Value |
|---|---|---|
| Highest education | | |
| Primary | N (%) | 70 (34.8) |
| Secondary | N (%) | 108 (53.7) |
| University | N (%) | 23 (11.5) |
| Religion | | |
| Christian | N (%) | 197 (98.0) |
| Muslim | N (%) | 4 (2.0) |
| Ethnicity | | |
| Grassfield | N (%) | 196 (97.5) |
| Mbororo | N (%) | 5 (2.5) |
| Occupation | | |
| Civil servants | N (%) | 18 (9.0) |
| Self-employed | N (%) | 87 (43.3) |
| Traders | N (%) | 68 (33.8) |
| Private sector | N (%) | 28 (13.9) |
| Meal provider | | |
| Aunt | N (%) | 28 (13.9) |
| Brother/sister | N (%) | 17 (8.5) |
| Father | N (%) | 35 (17.4) |
| Mother | N (%) | 89 (44.3) |
| Uncle | N (%) | 32 (15.9) |
| Source of foodstuffs | | |
| Farm | N (%) | 86 (42.8) |
| Market | N (%) | 115 (57.2) |
| Child and adolescent characteristics | | |
| Sex | | |
| Male | N (%) | 92 (45.8) |
| Female | N (%) | 109 (54.2) |
| Age (months) | | |
| 2-9 | N (%) | 31 (15.4) |
| 10-19 | N (%) | 170 (84.6) |

| Maternal characteristics | Statistics | Value |
|---|---|---|
| Anthropometry | | |
| Weight (Kg) | Median (IQR) | 45.0 (32.0, 55.5) |
| Height (cm) | Median (IQR) | 149 (135.5, 157.0) |
| WAZ (underweight) | N (%) | 28 (13.9) |
| HAZ (stunted) | N (%) | 55 (27.4) |
| BAZ (Acute malnourished) | N (%) | 20 (10.0) |
| MUAC (Acute malnourished) | N (%) | 41 (20.4) |
| Health status | | |
| Malaria | N (%) | 21 (10.4) |
| Diarrhea | N (%) | 15 (7.5) |
| Typhoid | N (%) | 11 (5.5) |
| Anemia | N (%) | 20 (10.0) |
| Avitaminosis A | N (%) | 21 (10.4) |
| Clinical signs | | |
| Presence of bilateral oedema | N (%) | 0 (0.0) |
| Presence of Bitot spots | N (%) | 21 (10.4) |
| Presence of goiter | N (%) | 2 (1.0) |
| Colored tongue | N (%) | 14 (7.0) |
| Colored palms | N (%) | 40 (19.9) |
| Colored hair | N (%) | 25 (12.4) |
| Presence of fever | N (%) | 53 (26.4) |
| HIV regimen | | |
| Abacavir | N (%) | 34 (16.9) |
| Abacavir and efavirenz | N (%) | 10 (5.0) |
| Abacavir and lamivudine | N (%) | 1 (0.5) |
| Atazanavir | N (%) | 19 (9.4) |
| Dolutegravir | N (%) | 27 (13.4) |
| Efavirenz | N (%) | 45 (22.4) |
| Efavirenz and topinavir | N (%) | 1 (0.5) |
| Lamivudine | N (%) | 18 (9.0) |
| Lamivudine and efavirenz | N (%) | 1 (0.5) |
| Lopinavir | N (%) | 28 (13.9) |
| Ritonavir | N (%) | 17 (8.5) |
| Biochemistry | | |
| Viral load (RNA) | Median (IQR) | 1184 (76, 11687) |
| CD4 cell count (cell/mm$^3$) | Median (IQR) | 640 (359, 805) |
| Hemoglobin (g/dl) | Median (IQR) | 12.0 (10.4, 13.3) |
| Albumin (g/l) | Median (IQR) | 44.2 (36.7, 47.1) |
| Cholesterol total (g/l) | Median (IQR) | 154.0 (134.0, 184.0) |
| Triglycerides (g/l) | Median (IQR) | 65.0 (50.0, 86.0) |
| HDL-cholesterol (g/l) | Median (IQR) | 43.0 (35.0, 50.0) |
| LDL-cholesterol (g/l) | Median (IQR) | 100.0 (79.5, 122.0) |
| Chol/HDL ratio | Median (IQR) | 3.8 (3.2, 4.5) |

WAZ: weight-for-age, HAZ: height-for-age, BAZ: BMI-for-age, RNA: Ribonucleic acid, CD4: cluster of differentiation 4, LDL: low-density lipoprotein, HDL: high-density lipoproteins, IQR: interquartile range.

***Table 2.*** *Comparison of anthropometric, clinical and biochemical indices between children and adolescents (n= 201).*

| Variables | Children (n=31) | Adolescent (n=170) | *p-value* |
|---|---|---|---|
| Anthropometry | | | |
| *Boy* – Mean (SD) | | | |
| Weight-for-age | 0.04 (1.78) | -1.09 (1.17) | 0.046 |
| Height-for-age | -0.42 (2.15) | -1.66 (1.30) | 0.005 |
| BMI-for-age | 0.46 (1.53) | -0.21 (1.29) | 0.446 |
| *Girls* - Mean (SD) | | | |
| Weight-for-age | -0.82 (1.84) | -0.32 (1.15) | 0.280 |
| Height-for-age | -0.91 (1.84) | -1.26 (1.17) | 0.092 |
| BMI-for-age | -0.32 (1.28) | 0.36 (1.18) | 0.029 |
| Clinical variables – N (%) | | | |
| Presence of Bitot spots | 2 (6.5%) | 19 (11.2) | 0.433 |
| Presence of goiter | 1 (3.2%) | 1 (0.6) | 0.182 |
| Colored tongue | 5 (16.1%) | 9 (5.3) | 0.030 |
| Colored palms | 5 (16.1%) | 35 (20.6) | 0.565 |
| Colored hair | 3 (9.7%) | 22 (12.9) | 0.620 |
| Biochemical variables – Mean (SD) | | | |
| Hemoglobin (g/dl) | 11.31 (1.61) | 12.00 (2.02) | 0.073 |
| Albumin (g/l) | 42.52 (4.92) | 42.83 (6.70) | 0.758 |

| Variables | Children (n=31) | Adolescent (n=170) | *p-value* |
|---|---|---|---|
| Cholesterol total (g/l) | 177.32 (50.84) | 157.91 (35.95) | 0.011 |
| Triglycerides (g/l) | 92.06 (47.12) | 73.15 (39.84) | 0.019 |
| HDL-cholesterol (g/l) | 46.87 (13.97) | 42.86 (11.93) | 0.096 |
| LDL-cholesterol (g/l) | 111.71 (42.62) | 102.03 (30.86) | 0.235 |
| Chol/HDL ratio | 3.94 (0.97) | 3.83 (0.88) | 0.504 |

LDL: low-density lipoprotein, HDL: high-density lipoproteins, SD: standard deviation.

### *3.3. Dietary Habits and WASH Characteristics*

More than one-quarter of participants had good knowledge of a balanced diet (Table 3). One third had meals twice a day and almost all had breakfast, lunch and supper at home. One-third also experienced lack of appetite and close to half take dietary supplements. The main source of drinking water in the household was tap water and 45% of the households' cooking water came from the well. Toilets were available in all households of the participants.

***Table 3.*** *Dietary habits and WASH characteristics of study population (N = 201).*

| Characteristics | Statistics | Value |
|---|---|---|
| *Food habits* | | |
| Knowledge of balanced diet | N (%) | 56 (27.9) |
| Meal frequency per day | | |
| Any time hungry | N (%) | 61 (30.8) |
| Thrice | N (%) | 79 (39.9) |
| Twice | N (%) | 58 (29.3) |
| Personal selection of foods | N (%) | 1 (0.5) |
| Place where meals are taken | | |
| Home breakfast | N (%) | 193 (97.5) |
| Home morning snack | N (%) | 23 (11.5) |
| Home Lunch | N (%) | 193 (97.5) |
| Home evening snack | N (%) | 42 (21.0) |
| Home supper | N (%) | 199 (100.0) |
| Lack of appetite | N (%) | 59 (29.4) |
| Intake of dietary supplements | N (%) | 94 (46.8) |
| *Water, hygiene and sanitation* | | |
| Source of drinking water | | |
| Water stream | N (%) | 24 (11.9) |
| Tap water | N (%) | 142 (70.6) |
| Well | N (%) | 35 (17.6) |
| Source of cooking water | | |
| Water stream | N (%) | 46 (22.9) |
| Tap water | N (%) | 64 (31.8) |
| Well | N (%) | 91 (45.3) |
| Defecating facilities | | |
| Toilet | N (%) | 201 (100.0) |

### *3.4. Food Frequency Intake and Factors Associated with Both Underweight and Acute Malnutrition*

Table 4 reports the frequency of consumption of food items of the study population. Out of the 45 food items recorded, rice was the most commonly consumed food items with a median frequency intake of 2 to 4 times a week. The least consumed food item was grapes with median frequency intake of once per year. The intake of starchy foods and fats varied mainly from 1 to 6 times per week while that of vegetables was from 1 to 7 times a week. The consumption of dairy products, flesh foods and sweet products varied from once a month to 6 times per week. The intake of fruits ranged from once per month to 7 times a week while that of pulses ranged between once per year and 6 times per week. All the food groups had a median frequency intake of 2 to 4 times per week except dairy products and pulses that had a median frequency intake of once per week. The frequency intake of dairy products was negatively associated with underweight (age-adjusted OR =0.678; 95%CI 0.461-0.997; p = 0.048) while the intake of flesh foods was positively associated with MUAC-based acute malnutrition (age-adjusted OR = 1.555; 95%CI 1.096-2.209; p = 0.013).

### *3.5. Factors Associated with Undernutrition*

Results from univariate analysis showed that sex (p = 0.020), and avitaminosis A (p = 0.049) were significantly associated with undernutrition (table 5). After controlling for the 18 variables in a multivariate analysis, the following variables were significant: sex (p = 0.029), age (p = 0.018), occurrence of typhoid (p = 0.039) and occurrence of vitamin A deficiency (p = 0.004). Also, being a HIV-positive female was negatively associated with undernutrition compared to being a HIV-positive male (aOR = 0.378; 95%CI 0.157-0.908). Being a child between 2 and 9 years old was positively associated with undernutrition as compared to being an adolescent (aOR = 3.988; 95%CI 1.265-12.576). Having typhoid fever was positively associated with undernutrition (aOR = 7.250; 95%CI 1.105-47.579). Developing undernutrition was positively associated with the occurrence of vitamin A deficiency (aOR = 7.664; 95%CI 1.902-30.881).

### *3.6. Factors Associated with Underweight*

Regarding underweight (weight-for-age), age (p = 0.012) and LDL-cholesterol level (p = 0.015) were significant (Table 6). The results suggested that being a child aged 2-9 years was positively associated with underweight than being an adolescent aged 10-19 years (aOR = 7.864; 95%CI 1.588-38.939). Higher levels of LDL-cholesterol were positively associated with underweight (aOR = 1.048; 95%CI 1.009-1.088).

### *3.7. Factors Associated with Stunting*

Vitamin A deficiency (p = 0.030) and albumin (p = 0.014) were the two factors associated with stunting (Table 6). The occurrence of vitamin A deficiency positively associated with stunting (aOR = 4.384; 95%CI 1.157-16.608). Higher levels of albumin were positively associated with stunting (aOR = 1.107; 95%CI 1.021-1.201).

### *3.8. Factors Associated with Acute Malnutrition*

Acute malnutrition (BMI-for-age) presented in table 6 was

substantially related to age (p = 0.013), vitamin A deficiency (p = 0.005), and triglyceride level (p = 0.039). It appeared that being a child aged 2-9 years was more associated with acute malnutrition as compared to being an adolescent between 10 and 19 years old (aOR = 44.857; 95%CI 2.210-910.594). Developing vitamin A deficiency was positively associated with acute malnutrition (aOR = 73.939; 95%CI 3.569-1531.917). Higher levels of triglycerides were positively associated with acute malnutrition (aOR = 1.026; 95%CI 1.001-1.052). MUAC-based acute malnutrition did not exhibited associated factors.

***Table 4.*** *Frequency intake of food items and food groups of study population (N = 201).*

| Food items | Never | Once per year | Once per month | Once per week | 2-4 times/week | 5-6 times/week | Daily |
|---|---|---|---|---|---|---|---|
| *Starchy foods* | | | | | | | |
| Potatoes | 0 (0.0) | 2 (1.0) | 80 (38.6) | 84 (40.6) | 35 (16.9) | 0 (0.0) | 0 (0.0) |
| Cocoyam/ Achu | 0 (0.0) | 2 (1.0) | 78 (39.0) | 1 (0.5) | 27 (13.5) | 0 (0.0) | 0 (0.0) |
| Cassava / Waterfufu | 0 (0.0) | 1 (0.5) | 52 (26.0) | 1 (0.5) | 43 (21.5) | 0 (0.0) | 0 (0.0) |
| Plantain | 0 (0.0) | 1 (0.5) | 54 (26.9) | 104 (51.7) | 42 (20.9) | 0 (0.0) | 0 (0.0) |
| Rice | 0 (0.0) | 0 (0.0) | 1 (0.5) | 35 (17.4) | 109 (54.2) | 56 (27.9) | 0 (0.0) |
| Corn /corn fufu | 0 (0.0) | 0 (0.0) | 41 (20.4) | 105 (52.2) | 53 (26.4) | 0 (0.0) | 0 (0.0) |
| Yam | 0 (0.0) | 77 (38.3) | 102 (50.7) | 19 (9.4) | 3 (1.5) | 0 (0.0) | 0 (0.0) |
| Spaghetti | 0 (0.0) | 11 (5.5) | 68 (34.0) | 83 (41.5) | 38 (19.0) | 0 (0.0) | 0 (0.0) |
| Bread | 1 (0.5) | 0 (0.0) | 34 (16.9) | 92 (45.8) | 69 (34.3) | 5 (2.5) | 0 (0.0) |
| *Fruits* | | | | | | | |
| Apple | 4 (2.0) | 45 (22.4) | 109 (54.2) | 3 (1.5) | 40 (19.9) | 0 (0.0) | 0 (0.0) |
| Banana | 1 (0.5) | 2 (1.0) | 50 (24.9) | 85 (42.3) | 59 (29.4) | 3 (1.5) | 1 (0.5) |
| Grape | 46 (22.9) | 82 (40.8) | 69 (34.3) | 3 (1.5) | 1 (0.5) | 0 (0.0) | 0 (0.0) |
| Melon | 0 (0.0) | 10 (5.0) | 59 (29.1) | 81 (40.3) | 48 (23.9) | 2 (1.0) | 1 (0.5) |
| Orange | 1 (0.5) | 27 (13.4) | 101 (50.2) | 65 (32.3) | 6 (3.0) | 0 (0.0) | 0 (0.0) |
| Pears | 0 (0.0) | 9 (4.5) | 54 (26.9) | 89 (44.3) | 45 (22.4) | 4 (2.0) | 0 (0.0) |
| Other fruits | 0 (0.0) | 27 (13.4) | 132 (65.7) | 39 (19.4) | 3 (1.5) | 0 (0.0) | 0 (0.0) |
| *Vegetables* | | | | | | | |
| Cabbage | 4 (2.0) | 25 (12.4) | 118 (58.7) | 49 (24.4) | 5 (2.5) | 0 (0.0) | 0 (0.0) |
| Carrots | 6 (3.0) | 13 (6.5) | 121 (60.2) | 57 (28.4) | 4 (2.0) | 0 (0.0) | 0 (0.0) |
| Green beans | 29 (14.4) | 13 (6.5) | 99 (49.3) | 54 (26.9) | 6 (3.0) | 0 (0.0) | 0 (0.0) |
| Huckle berry | 2 (1.0) | 4 (2.0) | 52 (25.9) | 105 (52.2) | 37 (18.4) | 1 (0.5) | 0 (0.0) |
| Tomato | 0 (0.0) | 1 (0.5) | 17 (8.5) | 95 (47.3) | 77 (38.3) | 8 (4.0) | 3 (1.5) |
| Green leafy vegetables | 0 (0.0) | 23 (11.4) | 107 (53.2) | 66 (32.8) | 4 (2.0) | 0 (0.0) | 0 (0.0) |
| *Dairy products* | | | | | | | |
| Ice cream | 12 (6.0) | 59 (29.4) | 107 (53.2) | 18 (9.0) | 4 (2.0) | 1 (0.5) | 0 (0.0) |
| Yoghurt | 15 (7.5) | 39 (19.4) | 103 (51.2) | 36 (17.9) | 8 (4.0) | 0 (0.0) | 0 (0.0) |
| Milk drink | 1 (0.5) | 16 (8.0) | 68 (33.8) | 86 (42.8) | 28 (13.9) | 2 (1.0) | 0 (0.0) |
| Other milk drinks | 0 (0.0) | 15 (7.5) | 99 (49.3) | 64 (31.8) | 22 (10.9) | 0 (0.0) | 0 (0.0) |
| *Flesh foods* | | | | | | | |
| Beef | 0 (0.0) | 7 (3.5) | 89 (44.3) | 80 (39.8) | 25 (12.4) | 0 (0.0) | 0 (0.0) |
| Chicken | 0 (0.0) | 23 (11.4) | 87 (43.3) | 65 (32.2) | 25 (12.4) | 1 (0.5) | 0 (0.0) |
| Fish | 0 (0.0) | 0 (0.0) | 33 (16.4) | 98 (48.8) | 68 (33.8) | 2 (1.0) | 0 (0.0) |
| Eggs | 4 (2.0) | 11 (5.5) | 68 (33.8) | 73 (36.3) | 43 (21.4) | 2 (1.0) | 0 (0.0) |
| Pork | 12 (6.0) | 21 (10.4) | 88 (43.8) | 67 (33.3) | 13 (6.5) | 0 (0.0) | 0 (0.0) |
| *Fats and sweets* | | | | | | | |
| Cakes | 1 (0.5) | 27 (13.4) | 95 (47.3) | 65 (32.3) | 13 (6.5) | 0 (0.0) | 0 (0.0) |
| Candy | 1 (0.5) | 12 (6.0) | 64 (31.8) | 82 (40.8) | 40 (19.9) | 2 (1.0) | 0 (0.0) |
| Chips | 3 (1.5) | 29 (14.4) | 108 (53.7) | 52 (25.9) | 8 (4.0) | 0 (0.0) | 0 (0.0) |
| Cookies | 1 (0.5) | 28 (13.9) | 88 (43.8) | 69 (34.3) | 15 (7.5) | 0 (0.0) | 0 (0.0) |
| Doughnuts | 2 (1.0) | 29 (14.4) | 116 (57.7) | 52 (25.9) | 2 (1.0) | 0 (0.0) | 0 (0.0) |
| Fruit flavor drinks | 0 (0.0) | 15 (7.5) | 113 (56.2) | 58 (28.9) | 15 (7.5) | 0 (0.0) | 0 (0.0) |
| Pie | 0 (0.0) | 0 (0.0) | 56 (27.9) | 91 (45.3) | 53 (26.4) | 1 (0.5) | 0 (0.0) |
| Soft drinks | 0 (0.0) | 7 (3.5) | 83 (41.3) | 76 (37.8) | 35 (17.4) | 0 (0.0) | 0 (0.0) |
| Palm oil | 0 (0.0) | 0 (0.0) | 2 (1.0) | 31 (15.4) | 104 (51.7) | 64 (31.8) | 0 (0.0) |
| Refined oils | 0 (0.0) | 0 (0.0) | 0 (0.0) | 132 (65.7) | 68 (33.8) | 1 (0.5) | 0 (0.0) |
| Other fats & sweets | 0 (0.0) | 0 (0.0) | 0 (0.0) | 173 (86.1) | 26 (12.9) | 1 (0.5) | 0 (0.0) |

***Table 5.*** *Univariate and multivariate analysis of risk factors of undernutrition among study population (n= 201).*

| Variables | Undernutrition | | Undernutrition | |
|---|---|---|---|---|
| | OR (95%CI) | *P* | aOR (95%CI) | *P* |
| Sex | | | | |
| Female | 0.491 (0.270; 0.893) | 0.020 | 0.378 (0.157; 0.906) | 0.029 |
| Male | 1 | | 1 | |
| Age (years) | | | | |
| 2-9 | 1.357 (0.615; 2.994) | 0.450 | 3.988 (1.265; 12.576) | 0.018 |
| 10-19 | 1 | | 1 | |

| Variables | Undernutrition | | Undernutrition | |
|---|---|---|---|---|
| | OR (95%CI) | *P* | aOR (95%CI) | *P* |
| Mother education | | | | |
| Primary | 1.220 (0.661; 2.250) | 0.526 | 0.928 (0.382; 2.256) | 0.870 |
| Greater than primary | 1 | | 1 | |
| Malaria | | | | |
| Yes | 2.133 (0.713; 6.379) | 0.175 | 0.631 (0.119; 3.349) | 0.589 |
| No | 1 | | 1 | |
| Diarrhea | | | | |
| Yes | 2.013 (0.133; 1.793) | 0.488 | 0.170 (0.018; 1.650) | 0.126 |
| No | 1 | | 1 | |
| Typhoid | | | | |
| Yes | 2.600 (0.763; 8.856) | 0.127 | 7.250 (1.105; 47.579) | 0.039 |
| No | 1 | | 1 | |
| Anemia | | | | |
| Yes | 1.113 (0.422; 2.937) | 0.828 | 3.533 (0.804; 15.521) | 0.095 |
| No | 1 | | 1 | |
| Avitaminosis A | | | | |
| Yes | 2.500 (1.003; 6.231) | 0.049 | 7.664 (1.902; 30.881) | 0.004 |
| No | 1 | | 1 | |
| Hemoglobin (g/dl) | 0.949 (0.817; 1.102) | 0.949 | 0.912 (0.713; 1.167) | 0.465 |
| Albumin (g/l) | 1.006 (0.961; 1.054) | 0.786 | 1.070 (0.992; 1.154) | 0.082 |
| Cholesterol total (g/l) | 0.999 (0.991; 1.007) | 0.789 | 1.005 (0.962; 1.050) | 0.830 |
| Triglycerides (g/l) | 0.999 (0.991; 1.006) | 0.720 | 0.994 (0.981; 1.007) | 0.389 |
| HDL-cholesterol (g/l) | 0.990 (0.966; 1.014) | 0.415 | 0.930 (0.792; 1.091) | 0.370 |
| LDL-cholesterol (g/l) | 1.001 (0.992; 1.010) | 0.838 | 1.011 (0.986; 1.037) | 0.385 |
| Chol/HDL ratio | 1.193 (0.859; 1.658) | 0.292 | 0.551 (0.098; 3.087) | 0.498 |
| Viral load (RNA) | 1.000 (0.999; 1.001) | 0.614 | 1.000 (0.999; 1.001) | 0.902 |
| CD4 cell count (cell/mm$^3$) | 1.000 (1.000; 1.001) | 0.465 | 1.000 (0.999; 1.001) | 0.822 |
| Drinking water | | | | |
| Tap | 0.839 (0.443; 1.591) | 0.592 | 1.036 (0.392; 2.739) | 0.944 |
| Others (Well & stream) | 1 | | 1 | |

Legend: BMI: Body mass index; MUAC: Mid-upper arm circumference; OR: Odds ratio; 95%CI: 95% confidence interval; P: p-value.

***Table 6.*** *Multivariate analysis of risk factors of underweight, stunting and acute malnutrition among study population (n= 201).*

| Variables | Weigh-for-age | | Height-for-age | | BMI-for-age | | MUAC | |
|---|---|---|---|---|---|---|---|---|
| | aOR (95%CI) | *P* | aOR (95%CI) | *P* | aOR (95%CI) | *P* | aOR (95%CI) | *P* |
| Sex | | | | | | | | |
| Female | 0.368 (0.099; 1.365) | 0.135 | 0.421 (0.171; .036) | 0.060 | 0.128 (0.013; .233) | 0.075 | 1.353 (0.456; .013) | 0.586 |
| Male | 1 | | 1 | | 1 | | 1 | |
| Age (years) | | | | | | | | |
| 2-9 | 7.864 (1.588; 38.939) | 0.012 | 2.428 (0.728; .097) | 0.149 | 44.857 (2.210; 10.594) | 0.013 | 3.185 (0.920; 1.031) | 0.068 |
| 10-19 | 1 | | 1 | | 1 | | 1 | |
| Mother education | | | | | | | | |
| Primary | 0.371 (0.084; 1.645) | 0.192 | 1.069 (0.431; .648) | 0.886 | 0.204 (0.017; .438) | 0.209 | 0.794 (0.252; .504) | 0.694 |
| Greater than primary | 1 | | 1 | | 1 | | 1 | |
| Malaria | | | | | | | | |
| Yes | 4.780 (0.566; 40.390) | 0.151 | 0.998 (0.184; .405) | 0.998 | 2.734 (0.107; 0.062) | 0.543 | 2.244 (0.344; 4.655) | 0.398 |
| No | 1 | | 1 | | 1 | | 1 | |
| Diarrhoea | | | | | | | | |
| Yes | 1.397 (0.124; 15.782) | 0.787 | 0.314 (0.035; .788) | 0.298 | 0.001 (0.000; .0002) | 0.998 | 0.634 (0.064; .308) | 0.698 |
| No | 1 | | 1 | | 1 | | 1 | |
| Typhoid | | | | | | | | |
| Yes | 4.936 (0.659; 36.993) | 0.120 | 2.444 (0.388; 5.382) | 0.341 | 8.939 (0.143; 59.669) | 0.299 | 4.955 (0.558; 4.033) | 0.151 |
| No | 1 | | 1 | | 1 | | 1 | |
| Anemia | | | | | | | | |
| Yes | 0.940 (0.075; 11.764) | 0.962 | 4.385 (0.937; 0.528) | 0.061 | 0.344 (0.008; 5.712) | 0.584 | 0.614 (0.081; .677) | 0.638 |
| No | 1 | | 1 | | 1 | | 1 | |
| Avitaminosis A | | | | | | | | |
| Yes | 0.843 (0.080; 8.854) | 0.887 | 4.384 (1.157; 6.608) | 0.030 | 73.939 (3.569; 531.917) | 0.005 | 0.587 (0.062; .600) | 0.643 |
| No | 1 | | 1 | | 1 | | 1 | |
| Hemoglobin (g/dl) | 0.916 (0.630; 1.332) | 0.646 | 0.903 (0.699; .167) | 0.437 | 0.933 (0.474; .836) | 0.841 | 0.770 (0.580; .023) | 0.072 |
| Albumin (g/l) | 0.982 (0.876; 1.102) | 0.763 | 1.107 (1.021; .201) | 0.014 | 0.837 (0.649; .081) | 0.173 | 1.021 (0.933; .117) | 0.656 |
| Cholesterol total (g/l) | 1.004 (0.948; 1.063) | 0.901 | 1.004 (0.961; .049) | 0.862 | 0.995 (0.915; .081) | 0.899 | 0.998 (0.945; .054) | 0.937 |
| Triglycerides (g/l) | 1.008 (0.994; 1.022) | 0.260 | 0.995 (0.982; 1.007) | 0.402 | 1.026 (1.001; 1.052) | 0.039 | 1.003 (0.992; 1.014) | 0.561 |
| HDL-cholesterol (g/l) | 0.822 (0.640; 1.056) | 0.125 | 0.917 (0.776; 1.083) | 0.306 | 0.943 (0.689; 1.290) | 0.712 | 0.988 (0.814; 1.200) | 0.903 |
| LDL-cholesterol (g/l) | 1.048 (1.009; 1.088) | 0.015 | 1.021 (0.996; 1.048) | 0.104 | 0.998 (0.949; 1.049) | 0.930 | 0.997 (0.968; 1.026) | 0.827 |

| Variables | Weigh-for-age | | Height-for-age | | BMI-for-age | | MUAC | |
|---|---|---|---|---|---|---|---|---|
| | aOR (95%CI) | *P* | aOR (95%CI) | *P* | aOR (95%CI) | *P* | aOR (95%CI) | *P* |
| Chol/HDL ratio | 0.175 (0.014; 2.163) | 0.174 | 0.375 (0.061; 2.301) | 0.289 | 0.910 (0.049; 17.013) | 0.950 | 0.688 (0.074; 6.373) | 0.742 |
| Viral load (RNA) | 1.000 (0.999; 1.001) | 0.804 | 1.000 (0.999; 1.001) | 0.812 | 1.000 (0.999; 1.001) | 0.446 | 1.000 (0.999; 1.001) | 0.181 |
| CD4 cell count (cell/mm$^3$) | 0.999 (0.997; 1.001) | 0.539 | 1.000 (0.999; 1.001) | 0.903 | 1.000 (0.997; 1.002) | 0.707 | 1.000 (0.998; 1.001) | 0.743 |
| Drinking water | | | | | | | | |
| Tap | 0.928 (0.227; 3.802) | 0.918 | 1.271 (0.456; 3.538) | 0.647 | 0.236 (0.019; 2.891) | 0.259 | 3.155 (0.723; 13.761) | 0.126 |
| Others (Well & stream) | 1 | | 1 | | 1 | | 1 | |

Legend: BMI: Body mass index; MUAC: Mid-upper arm circumference; OR: Odds ratio; 95%CI: 95% confidence interval; P: p-value.

# 4. Discussion

In this study, a high prevalence of undernutrition among children and adolescents was recorded. Among the study participants, stunting was the most frequent form of undernutrition. A different prevalence of undernutrition and acute malnutrition among HIV-infected children aged 2 to 19 years old was reported by Jesson and Leroy [8] in some Central and Western African countries including Cameroon. These authors reported overall prevalence of undernutrition, termed as malnutrition, and acute malnutrition to be 42.0% and 9.0% in Benin, Burundi, Cameroon, Côte d'Ivoire, Mali, Chad and Togo. On the contrary, the prevalence of stunting, termed as chronic malnutrition, in this study was similar to that of Jesson and Leroy [8] that reported a prevalence of 26.0%. The prevalence of stunting among studied adolescents were significantly higher as compared to that of Kenyan adolescents, 20.7% ($p = 0.041$) while the prevalence of underweight was significantly lower than that of Kenyan counterparts, 27.5% ($p < 0.001$) [19].

Balance and variety in a healthy diet are essential for an optimal nutrition. This study showed that all the food groups had a median frequency intake of 2 to 4 times a week except dairy products and pulses that had a median frequency intake of once per week. It was also noticed a decline in the consumption of dairy products among children and teenagers which was concomitant with an increase in consumption of sweetened beverages. This is attributed to increased autonomy in beverage choice, availability of other beverages in the household, and demographic factors, including income, sex, race, and television-watching habits [20-22]. The increased consumption of dairy products is associated with underweight observed in this study is in line with the findings of Herber et al. [23] where milk consumption was associated with a reduced probability of being underweight or stunted by 2.1 and 3.4 percentage points, respectively among children aged 6 to 59 months. Moreover, a cross-sectional analysis of data from US children aged 2–10 years participating in NHANES 1999–2004 showed a positive association between dairy product intake and BMI [24]. Krebs et al. [25] reported that meat consumption was associated with reduced likelihood of stunting among infants and toddlers. This is inconsistent with the observed link between the intake of flesh foods and MUAC-based acute malnutrition in this study. However, limited research exists to portray the relationship between meat consumption and undernutrition.

There are numerous and multifaceted causes of undernutrition. These causes were intertwining with each other in this research. The most immediate determinants of undernutrition and its bordered forms were age, sex, avitaminosis A, occurrence of typhoid fever, high levels of albumin, LDL-cholesterol, and triglycerides. In the present study, children were more vulnerable to undernutrition, underweight and acute malnutrition than adolescents. Similar trends were obtained by Jesson and Leroy [8] who observed that the risk of stunting was reduced in HIV-positive children aged 5 to 10 years compared to those aged 2 to 5 years (aOR = 0.61, 95%CI: 0.38–0.99). None of the variables used in this study could explain this difference of susceptibility. However, it is well documented that household food insecurity increases the risk of undernutrition among children and adolescents [26]. This might suggest that children aged 2 to 9 years were more food insecure than adolescents of this study. In fact, adolescents are less susceptible to nutritional deprivation, infectious diseases and nutrient deficiencies than children [27, 28].

The finding that boys are more likely to be undernourished than girls is supported by a number of other studies. A pooled analysis of 35 longitudinal cohorts from 15 low- and middle-income countries demonstrated that male gender is a predictor of both wasting and stunting [29]. A recent analysis of DHS data from Africa analyzed sex differences in undernutrition and discovered that though differences were marginal, overall, boys were more at risk of developing undernutrition than girls. The biggest differences were found in children who were concomitantly wasted and stunted [30]. This difference was observed to be more pronounced in more severe forms of undernutrition and in more socio-economically deprived contexts. Divergent immune and endocrine systems appear to explain some of these disadvantages of boys as compared to girls [31].

Vitamin A deficiency (VAD) was found to be an important factor associated with stunting, acute malnutrition and undernutrition as a whole. To date, few studies have examined the association of VAD with stunting, wasting, underweight, and acute malnutrition. Inconsistent findings were yielded by various studies [32-35]. However, findings from experimental studies suggest that vitamin A may affect growth through the regulation of growth hormone (GH) and thyroid-stimulating hormone beta genes. Deficiency of retinoic acid is associated with reduced secretion of GH from the pituitary gland, and causes a marked reduction in body weight in rats [36-38].

It was also noticed that children and adolescents suffering from typhoid fever were likely to be undernourished. No

study has also documented the biological mechanism by which typhoid causes undernutrition. However, a large number of studies have illustrated a bidirectional interaction of malnutrition and infection [39]. It is well-known that certain pathogens affect the nutritional status by reducing the dietary intake and intestinal absorption as well as increasing losses of endogenous nutrients and nutrient requirements [40]. In the mode of action of *Salmonellea typhi*, it invades the mucosa of the small and large intestines and produces toxins. This invasion stimulates the release of pro-inflammatory cytokines which induce an inflammatory reaction. The acute inflammatory response causes diarrhoea and may lead to ulceration and destruction of the mucosa [41]. Based on this pathogenesis, it can therefore be hypothesized that typhoid will likely reduce intestinal absorption of nutrients while increasing losses of endogenous nutrients and nutrient requirements thereby promoting undernutrition.

Stunting, a chronic consequence of undernutrition, was found to be correlated to increasing levels of albumin in this study. This result is different from that of Febriani et al. [42] that did not observe a significant correlation between stunting and albumin levels among children under 5 years. This delineated effect could be the reflection of causative factors of stunting.

A marked association between high levels of LDL-cholesterol and underweight was observed in children and adolescents. This finding was consistent with that of Sakamoto et al. [43] that showed low BMI was associated with future risk of LDL-cholesterol elevation independent of baseline lipid profiles and subsequent weight changes in women. High levels of triglycerides were also associated with acute malnutrition. High levels of triglycerides were also earlier reported among undernourished children [44]. The authors indicated that increased levels of total triglycerides could result from a defect in the clearance of these lipid fractions due to depressed activity of lipoprotein lipase. The influence of these biochemical parameters on underweight, stunting and malnutrition of children and adolescents in the present study calls for further investigations to better define the contribution in the nutritional status of HIV positive children and adolescents. However, the literature supports the differential levels and modulatory factors of human nutritional status as function of set of population [45].

This study presents several limitations. First, children and adolescents recruited for this research were mainly those who had access to the pediatric daycare of the Bamenda Regional Hospital located in the urban area, which make these results difficult to extrapolate to rural population. Secondly, the study design used in this study cannot allow generalizing the findings to all HIV-positive children and adolescents aged 2 to 19 years. Finally, this study was unable to elucidate the outlined link between higher levels of albumin and stunting.

# 5. Conclusion

In summary, HIV-positive children and adolescents consumed all food groups frequently except dairy products and pulses. The prevalence of undernutrition characterized by underweight, stunting and acute malnutrition was very high among the target population. The main associated factors of undernutrition among HIV-positive participants were being a male, being a child aged 2 to 9 years, occurrence of typhoid fever and vitamin A deficiency. Dyslipidemia notably hypercholesterolemia, high levels of LDL- and HDL-cholesterol was prevalent among HIV-positive children and adolescents. Factors associated with underweight, stunting and acute malnutrition were being a child aged 2 to 9 years and high LDL-cholesterol levels, vitamin A deficiency, and high triglycerides levels. Thus, the health care system should put an emphasis on the diet component of HIV program with a special focus on vitamin A-rich foods and vitamin A supplements alongside with dairy products. Special attention should be devoted to good hygiene practices among HIV-positive children and adolescents to prevent typhoid pathogen contamination and treat it if occurs to minimize the risk of undernutrition. Routine check of anthropometric parameters should be conducted to avoid severe presentations of all forms of undernutrition. Furthermore, the high prevalence of dyslipidemia acknowledges the need for prompt reoriented nutrition intervention and the necessity of a better understanding of the coexistence of undernutrition and dyslipidemia.

# Conflict of Interests

The authors declare that no competing interests exist.

# Authors' Contributions

CTA contributed in the design and follow up of the experiments, preparation and revision of the manuscript, SFUB and NAE analyzed the data and reviewing the manuscript, NTA and TSA took part in designing and carrying out of the study, EAR and TBC contributed in the revision of the manuscript.

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