

## RESEARCH ARTICLE

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# Malnutrition status and associated factors among HIV-positive patients enrolled in ART clinics in Zimbabwe

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## Abstract

**Background:** Sub-Saharan Africa suffers from a high burden of undernutrition, affecting 23.2% of its population, and in 2015 constituted 69% of the estimated people living with Human Immunodeficiency Virus (HIV) globally. Zimbabwe, in Southern African has a HIV prevalence of 14.7%, but malnutrition (under- and over-nutrition) in this population has not been characterized. A nationally representative survey was therefore conducted to determine malnutrition prevalence and associated factors among HIV-positive adults ( $\geq 15$  years) enrolled at antiretroviral therapy (ART) clinics in Zimbabwe.

**Methods:** Height and weight measurements were taken for all enrolled participants who had attended their scheduled clinic review visits. Malnutrition was determined using body mass index (BMI) calculations and classified as undernutrition ( $< 18.5$  kg/m<sup>2</sup>), normal (18.5–24.9 kg/m<sup>2</sup>) or over-nutrition ( $\geq 25$  kg/m<sup>2</sup>). Multivariate-adjusted odds ratios (aOR) were used to assess factors associated with undernutrition and over-nutrition.

**Results:** Of 1,242 HIV-positive adults interviewed, 849 (69%) were female and median age was 41 years (IQR, 34–49). The majority (93%) were on ART with a median treatment duration of 3 years (IQR, 1.1–4.3) and 581 (56%) had advanced HIV disease and a median CD4 cell count of 348 cells/uL (IQR, 174–510) at their last scheduled visit. There were 776 (63.6%) who had a normal BMI, 122 (10%) who had under-nutrition (1.4%-severe; 1.5%-moderate; 7.1%-mild) and 322 (26.4%) who had over-nutrition (18.4%-overweight; 8%-obesity). Females and those of older age (35–44 years and  $\geq 45$  years) versus 15–24 years were less likely to have undernutrition. Those reporting difficulty in accessing food in the past month [aOR = 1.67 (95%CI, 1.10–2.55)] and who had advanced HIV disease [aOR = 2.25 (95% CI, 1.34–3.77)] were more likely to have undernutrition. Being overweight or obese was more likely in females [aOR = 3.86 (95% CI, 2.72–5.48)], in those age  $\geq 45$  years [aOR = 2.24 (95% CI, 1.01–5.04)], those with higher wealth quintile and those with CD4 > 350 cells/mL [aOR = 4.85 (95% CI, 1.03–22.77)].

**Conclusion:** Zimbabwe faces two types of nutritional disorders; undernutrition and overweight / obesity, in its HIV-infected population, both of which are associated with increased morbidity and mortality. This may reflect a shift in the pattern of HIV/AIDS from being a highly fatal infectious disease to a chronic manageable condition.

**Keywords:** HIV, Malnutrition, Zimbabwe, Operational research

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## Background

There is increasing interest globally about malnutrition which directly affects one in three people living in the world [1], and refers to both undernutrition and over-nutrition [2]. Malnutrition and dietary factors are important risk factors for the global burden of diseases such as diabetes [3], cardiovascular disease [4], and tuberculosis [5, 6]. According to the 2016 Global Nutrition report, the economic consequences of malnutrition represent losses of 11% of Gross Domestic Product (GDP) every year in Africa and Asia, whereas preventing malnutrition delivers US\$16 in returns on investment for every US\$1 spent [1].

Sub-Saharan Africa in particular has the highest prevalence estimates of undernourishment in the world, with 23.2% of its population affected [7]. Likewise, the region has the highest burden of Human Immunodeficiency Virus (HIV) infection, constituting 69% of the estimated 36.7 million people living with HIV globally in 2015 [8]. HIV infection results in functionally defective metabolic ability at the individual level to absorb, store and utilize nutrients thus resulting in nutrient deficiencies, compromised immunity and increased risk of acquiring infectious diseases [9]. Insufficient food intake, together or with malabsorption, result in further progression of HIV-disease [10], and the subsequent weight loss and severe malnutrition that ensue are significant predictors of Acquired Immune Deficiency Syndrome (AIDS) related morbidity and mortality [11]. Despite the high global burden of HIV/AIDS, between 2010 and 2015 there has been more than a two-fold increase in the number of HIV-positive people receiving antiretroviral therapy (ART), which reached 10.3 million in eastern and southern Africa, the world's most affected regions. The scale up of ART has resulted in AIDS-related deaths in the region decreasing by 36% since 2010. While this is good news, there are certain factors associated with poor outcomes. For example, in sub-Saharan Africa, malnutrition in the form of low body mass index (BMI) is common at ART initiation ranging from 10% to 33% [12–15] and this is associated with poor treatment outcomes and increased mortality [13, 16].

Zimbabwe is one of the sub-Saharan countries worst affected by the HIV epidemic with an HIV prevalence of 14.7% (14.66–14.71%) among adults aged 15–49 years according to the 2015 national HIV estimates [17]. This translates to an estimated 1.4 million people aged 15 years and older living with HIV, although as of December 2015, only 788,000 (56%) were enrolled on ART (source = National ART Programme). Zimbabwe's gross domestic product per capita in 2015 was US\$924,10 compared to US\$1,588.50 for the whole sub-Saharan Africa region [18]. Currently there is inadequate information on

malnutrition prevalence among people living with HIV (PLHIV) in Zimbabwe and anecdotal evidence also suggests that nutritional assessment, care and support for PLHIV are weak. In line with Ministry of Health and Child Care in Zimbabwe (MoHCC) priorities, nutrition in people living HIV is a priority under the focal area of care, treatment and mitigation in the Zimbabwe National HIV/AIDS Strategic Plan (ZNASP) II 2011-2015 document. The MoHCC therefore commissioned a study to better understand the interactions between HIV and nutrition in the country. The study was aimed at determining i) prevalence of malnutrition and ii) factors associated with both undernutrition and over-nutrition among PLHIV enrolled at ART clinics in Zimbabwe.

## Methods

### Study design

A nationally representative analytical cross-sectional study design was used.

### Study participants and sampling

A list of 792 health facilities providing HIV treatment and care services inclusive of ART as of 31<sup>st</sup> December 2012 was used as the sampling frame for this study. In order to keep the study logistically and financially feasible, sites which had supported less than 400 HIV-positive patients through HIV treatment and care services by 31<sup>st</sup> December 2012 were excluded from the sampling frame. Of the remaining 235 health facilities providing HIV treatment and care services to  $\geq 400$  patients, a total of 31 health facilities were sampled using a probability proportional to size (PPS) sampling criterion [19]. The PPS sampling was done to ensure sampling of a range of ART sites that are representative of Zimbabwe whilst taking into account all the 10 geographical regions. The minimum required sample size of HIV-positive clients enrolled in ART clinics regardless of age was 1,420 assuming that the prevalence of malnutrition among adult PLHIV was 10.3% [12], without using a population correction factor, and using a design effect of 2, a 95% confidence interval, a 2.5% margin of error and assuming a response rate of 80%.

Confirmed HIV-positive individuals who were enrolled in HIV treatment and care at the selected health facilities providing ART services were targeted for this survey. Overall there were 1,527 study respondents, however this paper focused only on the 1,242 participants aged  $\geq 15$  years and consisted of non-pregnant women and men. This excluded 285 participants who consisted of pregnant/lactating women and children  $< 15$  years and were reserved for a separate paper. Patients who had attended the health facility for their scheduled HIV treatment and care appointment visit

were recruited and interviewed prior to or after being attended to by a health worker. Voluntary written consent was sought from those aged  $\geq 18$  years old whilst those aged 15–17 years were interviewed after obtaining parental assent if they were in the company of their parent or legal guardian.

#### HIV treatment and care services at health facility level

Once patients test HIV-positive in Zimbabwe, they are referred to a health facility that provides HIV treatment and care services. Patients are retested to confirm their HIV-positive status and are immediately registered in the pre-ART register. They are assigned a unique ART number and an individual ART care booklet. Adult patients (aged  $\geq 15$  years old) are also assessed for ART eligibility currently based on having World Health Organisation (WHO) clinical staging III or IV or having a CD4 cell count  $< 500$  cells/mL whilst all HIV-positive pregnant women since the end of 2013 are started on lifelong ART under Option B+ regardless of their CD4 cell count or WHO clinical staging. TB/HIV co-infected patients and those with chronic Hepatitis B are also initiated regardless of clinical or immunological status. Since the inception of the ART programme, the ART initiation criterion among adults has shifted from a CD4 cell count threshold of  $< 200$  cells/mL, to  $< 350$  cells/mL from 2011 to 2013 and eventually to  $< 500$  cells/mL from 2014 onwards in tandem with WHO guidelines [20–22]. ART regimens have become simpler and more efficacious over the years, moving from stavudine + lamivudine + nevirapine in the first 6 years of the ART programme since 2004 to tenofovir + lamivudine + nevirapine, and as of 2013, to tenofovir + lamivudine + efavirenz which is administered as a single, fixed-dose combination pill to be taken once daily.

In pre-ART care, patients are provided with cotrimoxazole prophylaxis (CPT). A patient is seen every 2 weeks for the first month after initiating ART, and then monthly for the next few months in order to assess treatment adherence, inter-current illnesses, adverse drug events, or immune reconstitution syndrome. If patients are stable after the initial 6 months, they are seen 6 months thereafter for clinical consultations. Recommended clinical indices assessed at every visit include patient weight, WHO clinical stage, screening of comorbidities such as TB, and ART and CPT adherence assessment through pill counts and self-reporting by patients. Other than prior to ART initiation, laboratory indices such as complete blood count (CBC) and CD4 counts should be done six months whilst serum alanine transaminase (ALT), serum creatinine, and of late in some regions viral load counts are conducted every 12 months.

#### Data variables and data collection

A three-day training workshop on familiarizing and pilot-testing the data collection tools and procedures was conducted prior to data collection. Data collectors consisted of health workers with prior experience of enumeration in other health-related surveys. Data collection was conducted between June and July of 2014 at all 31 selected ART clinics using an interviewer-administered questionnaire with coded responses. Questionnaires were also translated into the 2 main local languages (*Shona and Ndebele*) for respondents who were not conversant with English.

Variables collected included:- age, sex, educational level, rural/urban residence, history of TB treatment, the type of food consumed in the patient's household in the 7 days prior to the interview and household demographics such as number of household members, household assets and livestock and household income. Information on clinical characteristics such as CD4 cell count, WHO clinical staging, ART start date, and ART adherence was obtained from the individual patient care booklets for the interviewed patients. Weight and height measurements for the study respondents were measured and recorded at the start of the interview.

#### Study definitions

The main study outcome, nutritional status was based on body mass index (BMI) and calculated as weight in kilograms divided by height squared ( $\text{kg}/\text{m}^2$ ) and categorized as undernutrition (severe-  $< 16$   $\text{kg}/\text{m}^2$ ; moderate- 16.0 to 16.99  $\text{kg}/\text{m}^2$  and mild- 17.0 to 18.49  $\text{kg}/\text{m}^2$ ) and over-nutrition (overweight - 25.0 to 29.9  $\text{kg}/\text{m}^2$  and obesity-  $\geq 30$   $\text{kg}/\text{m}^2$ ) [23]. The wealth index, used in the survey and adopted from Filmer and Pritchett [24], was based on information collected from respondents on several items that measure household ownership of consumer durables which tend to be correlated with household wealth status, and these were used to quantify differences in household economic status. This wealth index variable was a continuous variable which was divided into 5 equal quintiles which were ranked from the lowest category (termed '*poorest quintile*') to the highest category (termed '*richest quintile*'). Food consumption score (FCS) which is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups was categorized as poor (0–21.4), borderline (21.5–35) and acceptable ( $> 35$ ) [25].

Having a household with income below US\$101.25/ person per month was categorized as having income below the Zimbabwe poverty datum line (PDL) for 2014 [26]. Likewise having household minimum consumption expenditure for food below US\$31.52/ person per month, which is necessary to ensure that each household member can consume a minimum food

basket representing 2,100 cal was defined as household income below the national food poverty line (FPL) for 2014 [26].

### Statistical analysis

Patient data collected in the questionnaires were coded and single entered by 7 data entry clerks into EpiData (version 3.1; EpiData Association, Odense, Denmark) and later cleaned for errors and analyzed using Stata/SE 13.0 (Stata Corp, 2013, Stata Statistical Software: Release 13.0, College Station, TX). Prior to statistical analysis, data were weighted using proportional weights, in order to account for unequal probabilities of selection in the sampling and also to account for the complex design of the survey (i.e., stratification and clustering). Percentages and frequencies were generated for categorical variables while means (standard deviations) or alternatively medians (inter-quartile ranges (IQR)) were calculated for continuous variables as deemed appropriate.

Associations between the primary outcome measures (undernutrition and over-nutrition) with socio-demographic, food security and vulnerability variables and clinical characteristics were determined using the Pearson's chi-squared test or alternatively Fischer's Exact test. Univariate and multivariate-adjusted odds ratios (aOR) and their respective 95% confidence intervals (CI) were calculated to determine factors associated with undernutrition and over-nutrition. Explanatory variables that were included in the multi-variate logistic regression models were those that had  $p$ -values  $\leq 0.25$  in bi-variate analysis with the outcome measures.  $P$ -values  $< 0.05$  were considered as statistically significant.

### Results

Table 1 shows the socio-demographic characteristics of the 1,242 HIV-positive adults who were enrolled in this study. There were 849 (68%) females and the overall median age of all participants was 41 years (IQR, 34–49). Slightly more study participants resided in the rural areas ( $n = 699$ , 56%) compared to urban areas ( $n = 543$ , 44%). The majority of respondents had attained secondary school education ( $n = 662$ , 57%) as their highest level of education while 467 (40%) had attained primary school education.

Table 2 shows food security and vulnerability characteristics among study respondents. Only 32 (3%) respondents had a poor household food consumption score whilst 261 (21%) had a borderline household food consumption score. Slightly over ten percent of respondents reported having previously received food aid whilst 389 (31%) reported having experienced difficulty in accessing food in the month preceding the survey. Approximately nine in ten respondents had a

**Table 1** Socio-demographic characteristics among HIV-positive adults enrolled in ART clinics in Zimbabwe

Characteristic	n	N	%	(95% CI)
Area				
Urban	543	1,242	43.7	(43.4–48.4)
Rural	699	1,242	56.3	(51.6–56.6)
Sex				
Male	393	1,242	31.6	(29.1–34.3)
Female	849	1,242	68.4	(65.7–70.9)
Age in Years				
15–24	51	1,242	4.1	(3.1–5.4)
25–34	288	1,242	23.2	(20.9–25.6)
35–44	464	1,242	37.4	(34.7–40.1)
45–54	265	1,242	21.3	(19.1–23.7)
$\geq 55$	174	1,242	14.0	(12.2–16.1)
Median (IQR)		1,242	41 (34; 49)	
Education Level				
Primary	467	1,159	40.3	(37.5–43.2)
Secondary	662	1,159	57.1	(54.2–59.9)
Higher	30	1,159	2.6	(1.8–3.7)
Missing	83	1,242	6.7	-
Wealth quintile				
Lowest	251	1,242	20.2	(18.1–22.5)
Second	252	1,242	20.3	(18.1–22.6)
Middle	243	1,242	19.6	(17.4–21.9)
Fourth	235	1,242	18.9	(16.8–21.2)
Highest	261	1,242	21.0	(18.8–23.4)

HIV Human Immunodeficiency virus, ART antiretroviral therapy, IQR interquartile range

household income below the poverty datum line and the food poverty line.

Clinical characteristics among HIV-positive adults enrolled in the study are shown in Table 3.

As shown in Table 3, the majority of respondents ( $n = 1,152$ , 93%) were on ART and their median duration on treatment was 3 years (IQR, 1.1–4.3). Self-reported adherence to ART in the month preceding the survey was high with 1,056 (93%) reporting adherence  $\geq 95\%$ . Nearly a third of respondents reported a history of TB treatment whilst 165 (13%) reported experiencing diarrhoea in the two weeks prior to the survey. Slightly more than half of the study respondents (56%) were documented with an illness characterised by WHO clinical stage 3 or 4 at the most recent visit. Only 349 (28%) study participants had a CD4 cell count measurement taken within six months of the interview date, and of these patients, the median CD4 cell count was 348 cells/mL (IQR, 174–510).

**Table 2** Food security and vulnerability characteristics among HIV-positive adults enrolled in ART clinics in Zimbabwe

Characteristic	n	N	%	(95% CI)
Household Food consumption score				
Poor (0–21.4)	32	1,242	2.6	(1.8–3.6)
Borderline (21.5–35)	261	1,242	21.0	(18.8–23.4)
Acceptable (>35)	949	1,242	76.4	(74.0–78.7)
Received Food aid				
No	1,100	1,242	88.6	(86.7–90.2)
Yes	142	1,242	11.4	(9.8–13.3)
Had difficulty accessing food in the past 30 days				
No	853	1,242	68.7	(66.0–71.2)
Yes	389	1,242	31.3	(28.8–34.0)
Household Income compared to PDL				
above PDL	135	1,074	12.6	(10.7–14.7)
Below PDL	939	1,074	87.4	(85.3–89.3)
Missing	168	1,242	13.5	-
Household Income compared to FPL				
above FPL	102	1,240	8.2	(6.8–9.9)
below FPL	1,138	1,240	91.8	(90.1–93.2)
Missing	2	1,242	0.2	-

HIV Human Immunodeficiency Virus, ART antiretroviral therapy, PDL poverty datum line, FDL food poverty line

The nutritional status according to BMI among enrolled study patients is shown in Fig. 1. The mean BMI for all HIV-positive patients was 23.5 kg / m<sup>2</sup> (standard deviation 9.4). The majority ( $n = 776$ , 63.6%) had a normal BMI, 122 (10%) had under nutrition which was severe in 17 (1.4%), moderate in 18 (1.5%) and mild in 87 (7.1%). There were 224 (18.4%) who were overweight and 98 (8%) with obesity: thus overall 26% of all respondents were classified with over-nutrition.

#### Factors associated with undernutrition

Factors associated with under-nutrition among enrolled study participants are shown in Table 4. Females when compared to males were less likely to have undernutrition [aOR = 0.31 (95% CI, 0.20–0.47)]. Compared to 15–24 year olds, those of older age were also less likely to have undernutrition; 35–44 years [aOR = 0.33 (95% CI, 0.14–0.76)] and ≥45 years [aOR = 0.43 (95% CI, 0.19–0.99)]. Those reporting difficulty in accessing food in the month prior to the survey had a higher likelihood of undernutrition [aOR = 1.67 (95%CI, 1.10–2.55)]. Having WHO clinical stage 3 or 4 was associated with a two-fold higher odds of having undernutrition [aOR = 2.25 (95% CI, 1.34–3.77)]. No significant differences were noted in risk factors for undernutrition when stratified by rural/urban residence.

**Table 3** Clinical characteristics among HIV-positive adults enrolled in ART clinics in Zimbabwe

Characteristic	n	N	%	(95% CI)
Experienced diarrhoea in the past 2 weeks				
No	1,077	1,242	86.7	(84.7–88.5)
Yes	165	1,242	13.3	(11.5–15.3)
ART status				
No	90	1,242	7.3	(5.9–8.8)
Yes	1,152	1,242	92.8	(91.2–94.1)
Duration on ART in years				
< 1	248	1,152	21.5	(19.2–24.0)
1–2	306	1,152	26.6	(24.1–29.2)
3–4	339	1,152	29.4	(26.9–32.1)
5–6	168	1,152	14.6	(12.7–16.7)
> 6	91	1,152	7.9	(6.5–9.6)
Median (IQR)		1,152	3 (1.1–4.3)	
ART adherence in the past month				
< 95%	83	1,139	7.3	(5.9–9.0)
≥ 95%	1,056	1,139	92.7	(91.0–94.1)
Missing	13	1,152	1.1	-
History of TB treatment				
No	894	1,238	72.2	(69.6–74.6)
Yes	344	1,238	27.8	(25.4–30.4)
Missing	4	1,242	0.3	-
Current WHO stage				
I/II	464	1,045	44.4	(41.4–47.4)
III/IV	581	1,045	55.6	(52.6–58.6)
Missing	197	1,242	15.9	-
Current CD4 cell count <sup>a</sup>				
≤ 50	26	349	7.5	(5.1–10.7)
51–200	75	349	21.5	(17.5–26.1)
201–350	75	349	21.5	(17.5–26.1)
351–500	78	349	22.4	(18.3–27.0)
> 500	95	349	27.2	(22.8–32.2)
Missing	893	1,242	71.9	-
Median (IQR)		349	348 (174–510)	

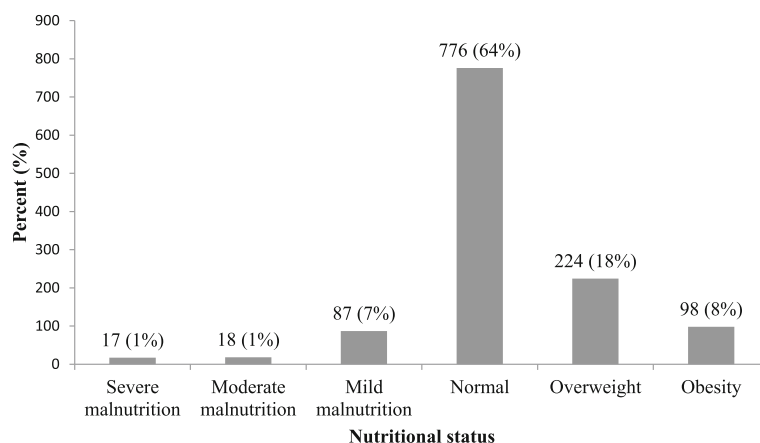
HIV Human Immunodeficiency Virus, ART antiretroviral therapy, IQR interquartile range, WHO World Health Organization

<sup>a</sup>Current CD4 cell count was taken as a CD4 cell count obtained with 6 months from date of data collection

#### Factors associated with over-nutrition

Table 5 shows factors associated with over-nutrition among enrolled HIV-positive study participants in ART clinics in Zimbabwe. Females when compared to males were nearly four times more likely to have over-nutrition [aOR = 3.86 (95% CI, 2.72–5.48)]. Over-nutrition was also higher among those aged ≥45 years [aOR = 2.24 (95% CI, 1.01–5.04)] in comparison to those aged 15–24





**Fig. 1** Nutritional status among HIV-positive adults enrolled in ART clinics in Zimbabwe. SAM = severe acute malnutrition; MAM = moderate acute malnutrition; HIV = Human Immunodeficiency Virus; ART = antiretroviral therapy

years old. The odds of having over-nutrition also increased with higher wealth quintile [highest versus lowest quintile – aOR = 2.84 (95%CI, 1.66–4.86)] and with increasing CD4 cell count of CD4 > 350 cells/mL [aOR = 4.85 (95% CI, 1.03–22.77)].

Multivariate regression for risk factors associated with over-nutrition was also carried out when stratified by rural/urban residence (data are not shown). The odds of over-nutrition increased with higher wealth quintile for urban dwellers only [highest versus lowest quintile – aOR = 3.39 (95%CI, 1.52–7.56)] whilst no differences were noted for rural dwellers. For rural dwellers, difficulty in accessing food in the past 30 days was associated with a lower odds of over-nutrition [aOR = 0.33(95%CI, 0.15–0.74)] whilst no differences were noted for urban dwellers.

## Discussion

This is the first nationally representative study in Zimbabwe conducted among HIV-positive patients enrolled in HIV treatment and care settings and aimed at determining prevalence of malnutrition and associated factors. Our study findings show that there is a high burden of malnutrition with about two in five of all HIV-positive patients being affected. Of note, the problem of malnutrition is a double-edged sword with both over-nutrition and under-nutrition being prevalent in this population. Over-nutrition affected approximately a quarter of all patients in comparison to under-nutrition which affected only a tenth of all HIV-positive patients. We also observed that under-nutrition was more prevalent among males compared to females, among older adolescents and young adults, among those who encountered difficulty accessing food in the past month and those with advanced HIV disease. We also observed that over-nutrition was higher among females, in the older age groups and also increased with higher wealth quintile and increasing CD4 cell count.

The strengths of this study include a large sample and the use of PPS sampling which ensured that our findings are nationally representative of HIV-positive patients enrolled in HIV treatment and care settings in Zimbabwe. The weight of study participants was measured using standardized and calibrated weight scales whilst height was measured using standardized height boards thus ensuring the body mass indices for these patients were current, accurate and comparable. A standardized questionnaire was also administered by trained data collectors and this ensured that all study participants were comparable. Study limitations may have included the possibility of recall bias by study respondents on the type of foods consumed in their households in the week preceding the survey and the frequency of their consumption. This may have led to incorrect calculation and misclassification of the household food consumption score. This study may not be representative of those HIV-positive patients who were enrolled in HIV treatment and care settings but missed their scheduled clinic review visits because they were too sick to attend the clinic. Whilst data were collected for pregnant and lactating women and those aged <15 years old, these were excluded from the analysis of nutritional status since their numbers were too small to allow meaningful inferences and also because body mass index is not an appropriate measure of nutritional status in pregnant and lactating women. Lastly, the use of BMI may underestimate the prevalence of obesity since it is reported to have low sensitivity and can miss a proportion of adults with excess body adiposity [27, 28].

In this study we observed that under-nutrition was less common when compared to over-nutrition among HIV-positive adults enrolled in ART clinics in Zimbabwe. This is in sharp contrast to other studies in the African region where malnutrition (BMI < 18.5 kg/m<sup>2</sup>) was more

**Table 4** Factors associated with under-nutrition among HIV-positive adults enrolled in ART clinics in Zimbabwe

Characteristic	n (%)	OR (95% CI)	aOR (95% CI)
<b>Area</b>			
Urban	58 (11.0)	reference	reference
Rural	64 (9.2)	0.82 (0.56; 1.19)	0.87 (0.57; 1.32)
<b>Sex</b>			
Male	66 (17.1)	reference	reference
Female	56 (6.7)	<b>0.35 (0.24; 0.51)</b>	<b>0.31 (0.20; 0.47)</b>
<b>Age in years</b>			
15–24	10 (20.4)	reference	reference
25–34	29 (10.4)	0.45 (0.2; 1)	0.50 (0.21; 1.20)
35–44	37 (8.0)	<b>0.34 (0.16; 0.74)</b>	<b>0.34 (0.15; 0.80)</b>
45–54	46 (10.7)	0.47 (0.22; 1.02)	<b>0.43 (0.19; 0.99)</b>
<b>Received Food aid</b>			
No	102 (9.5)	reference	reference
Yes	20 (14.1)	1.57 (0.94; 2.63)	1.36 (0.77; 2.39)
<b>Had difficulty accessing food in the past 30 days</b>			
No	72 (8.6)	reference	reference
Yes	50 (13.0)	<b>1.59 (1.08; 2.33)</b>	<b>1.67 (1.10; 2.55)</b>
<b>Experienced diarrhoea in the past 2 weeks</b>			
No	97 (9.2)	Reference	reference
Yes	25 (15.6)	<b>1.84 (1.14; 2.96)</b>	1.49 (0.89; 2.52)
<b>ART status and duration in years</b>			
Pre-ART	11 (12.5)	Reference	reference
< 1	33 (13.5)	1.09 (0.53; 2.27)	0.75 (0.41; 1.39)
1–2	28 (9.3)	0.72 (0.34; 1.51)	0.65 (0.34; 1.21)
3–4	27 (8.1)	0.62 (0.29; 1.3)	0.74 (0.36; 1.54)
5–6	16 (9.9)	0.77 (0.34; 1.73)	0.56 (0.21; 1.45)
> 6	7 (7.7)	0.58 (0.22; 1.58)	1.26 (0.57; 2.81)
<b>History of TB treatment</b>			
No	75 (8.5)	Reference	reference
Yes	47 (13.9)	<b>1.74 (1.18; 2.56)</b>	1.30 (0.84; 2.01)
<b>Current WHO stage</b>			
I/II	28 (6.1)	Reference	reference
III/IV	72 (12.6)	<b>2.2 (1.4; 3.47)</b>	<b>2.25 (1.34; 3.77)</b>
<b>Current CD4 cell count<sup>a</sup></b>			
≤ 50	8 (30.8)	reference	reference
51–200	10 (13.5)	0.35 (0.12; 1.02)	0.47 (0.14; 1.51)
201–350	8 (11.0)	<b>0.28 (0.09; 0.84)</b>	0.43 (0.13; 1.45)
≥ 350	18 (10.4)	<b>0.26 (0.10; 0.69)</b>	0.53 (0.18; 1.56)

OR odds ratio, aOR multivariate-adjusted odds ratio, CI confidence interval, HIV Human Immunodeficiency Virus, ART antiretroviral therapy, TB Tuberculosis, WHO World Health Organization

<sup>a</sup>Current CD4 cell count was taken as a CD4 cell count obtained with 6 months from date of data collection

NB: All odds ratios and 95% confidence intervals in bold font are statistically significant with p-values <0.05

common and as high as 26.3% [14] and 36% [29]. In one meta-analysis published in 2015, malnutrition (BMI < 18.5 kg/m<sup>2</sup>) was reported as one of the leading causes of hospital admission among HIV-positive adults in the Africa region [30]. Weight loss which leads to severe and moderate malnutrition is common in HIV infection and can be caused by low dietary intake due to loss of appetite, mouth ulcers, food insecurity and also due to malabsorption of macronutrients and an altered metabolism [31]. Men were more likely to have undernutrition compared to women, and we attribute this to the established fact that they present late for HIV treatment and care with advanced HIV disease and low CD4 counts in Zimbabwe [32] and other African settings [33, 34]. Lower CD4 cell counts have been found to be associated with severe and moderate malnutrition [14, 29] and these are also associated with increased mortality [35]. Similar to other studies, household food insecurity which affects the frequency of meals and dietary diversity of meals consumed in a household has been commonly reported as a predictor of poor nutritional status [36]. There were no differences in levels of undernutrition between PLHIV in rural and urban residences and this could be explained by our findings that show that study participants were generally from poor households given that the majority had household incomes below the national poverty datum line and food poverty line. Whilst urban dwellers may be perceived to have better food security and subsequently better nutritional status due to high economic activity, high levels of food insecurity and consequently malnutrition have been reported in Southern Africa and are related to rapid urbanization resulting in informal settlements [37].

In our sample, there were significantly higher proportions of HIV-positive patients who were overweight or obese compared with those at the other end of the scale. Our data also shows that the prevalence of being overweight and obese was slightly lower among HIV-positive women compared to women in the general population, with this data taken from women in the 2010-11 Zimbabwe Demographic and Health Survey (ZDHS) [38]. Interestingly, the population prevalence of women who were overweight or obese from this ZDHS (31%) was higher than the pooled prevalence for the Sub-Saharan Africa region at 23% [38], and this could be related to the 2011 World Bank poverty headcount ratio at US\$1.90 which was 21% for Zimbabwe compared to 44% for sub-Saharan Africa [39]. Increasing CD4 cell count was found to be associated with being overweight and obese and this concurs with findings from a follow-up of 17 ART cohorts in North America with sustained viral suppression [40, 41]. With women being more likely to be overweight or obese relative to men, this may again be related to their earlier entry into HIV care and ART initiation with relatively

**Table 5** Factors associated with over-nutrition among HIV-infected adults enrolled in ART clinics in Zimbabwe

Characteristic	n (%)	OR (95% CI)	aOR (95% CI)
<b>Area</b>			
Urban	163 (31.0)	reference	reference
Rural	159 (22.9)	<b>0.66 (0.51–0.85)</b>	0.9 (0.66–1.25)
<b>Sex</b>			
Male	51 (13.2)	reference	reference
Female	271 (32.5)	<b>3.16 (2.28–4.39)</b>	<b>3.86 (2.72–5.48)</b>
<b>Age in years</b>			
15–24	9 (18.4)	reference	reference
25–34	70 (25.1)	1.49 (0.69–3.22)	1.48 (0.65–3.36)
35–44	118 (25.6)	1.53 (0.72–3.25)	1.60 (0.72–3.56)
≥ 45	125 (29.0)	1.82 (0.86–3.85)	<b>2.24 (1.01–5.04)</b>
<b>Wealth quintile</b>			
Lowest	36 (14.5)	reference	reference
Second	65 (25.9)	<b>2.06 (1.31–3.23)</b>	<b>2.07 (1.29–3.33)</b>
Middle	60 (24.9)	<b>1.95 (1.23–3.09)</b>	<b>1.94 (1.19–3.17)</b>
Fourth	79 (34.5)	<b>3.10 (1.99–4.85)</b>	<b>3.15 (1.91–5.18)</b>
Highest	82 (32.7)	<b>2.86 (1.84–4.44)</b>	<b>2.84 (1.66–4.86)</b>
<b>Household Food consumption score</b>			
Poor (0–21)	7 (24.1)	reference	reference
Borderline (21.5–35)	55 (21.2)	0.85 (0.34–2.09)	0.92 (0.36–2.37)
Acceptable (>35)	260 (27.9)	1.22 (0.51–2.88)	1.06 (0.43–2.64)
<b>Had difficulty accessing food in the past 30 days</b>			
No	229 (27.4)	reference	reference
Yes	93 (24.2)	0.85 (0.64–1.12)	0.85 (0.62–1.16)
<b>Household Income compared to PDL</b>			
above PDL	47 (36.2)	reference	reference
Below PDL	238 (25.7)	<b>0.61 (0.41–0.9)</b>	0.84 (0.52–1.35)
<b>Household Income compared to FPL</b>			
above FPL	40 (40.4)	reference	reference
below FPL	282 (25.2)	<b>0.5 (0.32–0.76)</b>	<b>0.52 (0.31–0.87)</b>
<b>Duration on ART in years</b>			
Pre-ART	20 (22.7)	reference	reference
< 1	57 (23.4)	1.13 (0.76–1.67)	0.92 (0.59–1.45)
1–2	77 (25.6)	1.25 (0.85–1.83)	1.04 (0.67–1.63)
3–4	92 (27.5)	1.26 (0.80–1.99)	0.91 (0.54–1.54)
5–6	45 (27.8)	1.70 (1.00–2.87)	1.12 (0.61–2.04)
> 6	31 (34.1)	0.96 (0.54–1.72)	0.85 (0.45–1.59)
<b>Current WHO stage</b>			
I/II	132 (29.0)	reference	reference
III/IV	143 (25.0)	0.82 (0.62–1.08)	0.89 (0.65–1.20)

**Table 5** Factors associated with over-nutrition among HIV-infected adults enrolled in ART clinics in Zimbabwe (Continued)

<b>Current CD4 cell count<sup>a</sup></b>			
≤ 50	2 (7.7)	reference	reference
51–200	10 (13.5)	1.87 (0.38–9.19)	1.66 (0.32–8.62)
201–350	21 (28.8)	<b>4.85 (1.05–22.36)</b>	4.51 (0.92–22.15)
> 350	58 (33.5)	<b>6.05 (1.38–26.5)</b>	<b>4.85 (1.03–22.77)</b>

OR odds ratio, aOR multivariate-adjusted odds ratio, CI confidence interval, HIV Human Immunodeficiency Virus, ART antiretroviral therapy, PDL poverty datum line, FPL food poverty line, WHO World Health Organization

<sup>a</sup>Current CD4 cell count was taken as a CD4 cell count obtained with 6 months from date of data collection

NB: All odds ratios and 95% confidence intervals in bold font are statistically significant with p-values <0.05

higher CD4 cell counts compared to men [40, 41]. In many African settings including Zimbabwe, women have better access than men to HIV testing and treatment services through integration of HIV testing services in antenatal care settings [42], which act as an entry point into prevention-of-mother-to-child HIV transmission (PMTCT) services. Given that the majority of HIV-positive individuals enrolled in this study were on ART, there may also be a high prevalence of HIV-related lipodystrophy which has been reported, in one systematic review study, to develop within the first six months of therapy particularly with the use of stavudine [43]. Lipodystrophy can predispose HIV-positive individuals to cardiovascular disease [44], and hence the need to evaluate its prevalence, pathogenesis and prognosis in order to inform clinical management given the rapid national scale-up of ART and the subsequent longer survival as HIV-related mortality continues to decline. However, the use of stavudine based antiretroviral regimens has been phased out since 2013 due to these adverse events.

In addition, metabolic complications such as dyslipidemia, insulin resistance, and diabetes mellitus are also common among obese patients with well-controlled HIV-infection who are on long-term ART. These complications are also associated with increased risk of cardiovascular disease. Metabolic complications probably develop due to traditional risk factors such as obesity or genetic predisposition and HIV-specific and ART-specific contributions including chronic inflammation and immune activation [45]. Study participants who were of a higher wealth index were more likely to be overweight and obese but this trend was observed only among the urban participants. Unlike rural dwellers, where food insecurity is an issue, this trend is likely to be due to urban dwellers having better food security, having access to more refined and unhealthy food diets and also having more sedentary lifestyles [46]. Other studies have also found people of higher socioeconomic and wealth status [38] to have a higher prevalence of obesity and they are more likely to develop or have hypertension and diabetes [47].



This study has a number of implications. First, there is a double burden of undernutrition and over-nutrition amongst the country's population of HIV-positive patients enrolled in ART clinics. It is therefore important that health workers routinely assess and document weight and height measurements in individual health facility records to enable BMI monitoring as a proxy measure of nutritional status. A previous nationally representative record review of ART treatment outcomes among HIV-positive patients enrolled in ART clinics in Zimbabwe showed that approximately a quarter of all patients did not have recorded weight at ART initiation and this must change and improve [40]. Low baseline weight at ART initiation has been shown to increase the risk of ART attrition from care and mortality [40, 48] and given its association with late presentation with advanced HIV, this points towards a need to encourage early seeking of HIV testing services and subsequent ART initiation. Currently, the national ART programme is shifting towards an HIV 'treat-all' approach which promotes earlier ART initiation with promising improved treatment outcomes.

Second, the addition of micronutrient supplements to ART may provide increased nutritional recovery among HIV-positive patients with undernutrition [49, 50] and also more importantly improve adherence to ART among food-insecure adults as has been shown in Zambia [51] though no significant gains were observed with respect to weight and CD4 cell count response. However, despite improved health and ART adherence, perceptions among food-insecure HIV-positive adults participating in one Kenyan food supplementation program highlighted the inevitability of sharing food disbursements with people outside their families thus depleting the food available for them [52]. Any adoption of food supplementation programmes in ART clinics will therefore need to take this into consideration so as to ensure that the targeted malnourished HIV-positive patients benefit from these interventions.

Third, with obesity becoming prevalent in the HIV population on ART, HIV may change from being a highly fatal infectious disease into a chronic manageable disease that is associated with an elevated risk of cardiovascular-related conditions such as diabetes mellitus and hypertension. This calls for an urgent need to integrate the screening and management of hypertension and diabetes mellitus into HIV clinics [53], and particularly among patients who are overweight and obese.

## Conclusion

In conclusion, we have found that being overweight or obese is more prevalent than being underweight in HIV-positive patients enrolled in HIV treatment and care settings and on ART in Zimbabwe, and this is more common in females, in those of older age and in those with increasing wealth index. Given that over-nutrition

predisposes patients to cardiovascular-related conditions, there is an urgent need to integrate into HIV treatment and care services the screening of hypertension and diabetes mellitus in order to enable these conditions to be identified and appropriately managed to prevent cardiovascular complications.

## Abbreviations

AIDS: Acquired immunodeficiency syndrome; ALT: Serum alanine transaminase; aOR: Multivariate-adjusted odds ratios; ART: Antiretroviral therapy; BMI: Body mass index; CBC: Complete blood count; CI: Confidence interval; CPT: Cotrimoxazole preventive therapy; EAG: Ethics Advisory Group; FCS: Food consumption score; FPL: Food poverty line; GDP: Gross domestic product; HIV: Human Immunodeficiency Virus; IQR: Interquartile range; IUATLD: International Union Against Tuberculosis & Lung Disease; MoHCC: Ministry of Health and Child Care in Zimbabwe; MRCZ: Medical Research Council of Zimbabwe; PDL: Poverty datum line; PLHIV: People living with HIV; PMTCT: Prevention of mother-to-child transmission; PPS: Probability proportional to size; TB: Tuberculosis; WHO: World Health Organisation; ZDHS: Zimbabwe Demographic and Health Survey; ZNASP: Zimbabwe National HIV/AIDS Strategic Plan

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## Availability of data and materials

The data that support the findings of this study are available from the Ministry of Health and Child Care in Zimbabwe but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Ministry of Health and Child Care in Zimbabwe.

## Authors' contributions

KCT, TMA, BN, AC, MM, MB, BM and OM were involved in the design the study and data collection. KCT analysed data, wrote the first draft and subsequently coordinated the writing of the subsequent drafts and the final paper. ADH, TMA, BN, AC, MM, MB, BM and OM contributed to the review of all subsequent drafts of the paper. All authors read and approved the final paper.

## Competing interests

The authors declare that they have no competing interests.

## Consent for publication

Not applicable.

## Ethics approval and consent to participate

Ethics approval for the study was obtained prior to data collection from the Medical Research Council of Zimbabwe (MRCZ) and also Ethics Advisory Group (EAG) for the International Union Against Tuberculosis and Lung Disease (IUATLD), Paris, France. Voluntary written consent was sought from those aged  $\geq 18$  years old whilst those aged 15-17 years were interviewed after obtaining parental assent if they were in the company of their parent or legal guardian.

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