Serum zinc deficiency and associated factors among pre-ART and on-ART adults at Felege Hiwot referral hospital, Bahir Dar, Northwest Ethiopia

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Abstract: Background: Among several trace elements, zinc is a micronutrient that has a very significant role in maintaining immune function. Studies investigating trace elements status in people living with HIV/AIDS are few in Ethiopia. Hence, the present study was undertaken to investigate the concentration of serum zinc among sex and age matched pre ART and on ART adults. Methods: A cross-sectional study was conducted among 150 people living with HIV/AIDS (75 pre -ART and 75 on -ART) adults. Concentrations of zinc from serum were measured using fully automated flame atomic absorption spectrophotometer. CD4$^+$ T-cell count, CD8$^+$ T-cell count, hemoglobin determination, and Body Mass Index (BMI) were performed to evaluate the clinical status of study participants. Results: Serum zinc deficiencies were observed in 46 (30.7%) study participants. In multivariate logistic regression analysis, pre-ART study participants were nearly four times more likely at risk of serum zinc deficiency than on-ART study participants (AOR=3.56, 95% CI=1.52 to 8.32). Similarly, the odds of being serum zinc deficient were three times more in undernourished study participants than nourished study participants (AOR=2.61, 95% CI=1.02 to 6.67). Conclusion: A relatively high percentage of study participants had serum zinc deficiency. Early evaluation of serum zinc deficiency and zinc supplementation along with anti-retroviral treatment should be considered for pre-ART and under nourished adult people living with HIV/AIDS.

Keywords: Antiretroviral Therapy, Bahir Dar, HIV/AIDS, Serum Zinc Deficiency

1. Introduction

Back ground: - Trace elements are micronutrients that have recent attention as potential interventions to delay HIV progression [1]. Among several trace elements, zinc is an antioxidant micronutrient that have been playing a very significant role in maintaining immune function and neutralizing the reactive oxygen intermediates produced by activated macrophages and neutrophils in their response to microorganisms [2-5].

Serum and plasma measurements of trace elements, which are indicators of body stores, have shown that deficiencies are common among people living with HIV/AIDS (PLWHA). The deficiency of antioxidant trace elements in PLWHA is due to the excessive release of pro-oxidants and cytokines leading to increased utilization of antioxidants like zinc [6]. The depletion of trace elements may also occur through increased metabolic requirements, enhanced excretion, and intestinal mal-absorption [7]. This can result in an imbalance between pro-oxidants and antioxidants which may lead to increased oxidative stress which in turn may cause further damage to human cells, proteins and enzymes, thus accelerating HIV replication and mortality of the patient [8].

In HIV infection, low concentrations of serum micronutrients were frequently reported in the pre -ART era

and were linked with worsened HIV status and mortality [6]. Studies in the Nutrition for Healthy Living (NFHL) cohort suggest that extremes in higher micronutrient intake are increasingly more common in patients receiving ART. This trend is resulting in the transformation of serum micronutrient profiles in this population [9].

Studies investigating trace elements status of HIV infected populations have been done in developed countries and showed low serum or plasma levels [10, 11]. However, limited studies have been done in developing countries [12, 13]. No studies have been found in Ethiopia particularly in the study area on serum Zn deficiency status among on-ART and pre-ART PLWHA. Therefore, the present study aimed to assess the deficiency of serum zinc in relation to clinical status among adults who were on-ART and pre-ART at Felege Hiwot Referral Hospital in Bahir Dar, Northwest Ethiopia.

2. Methodology

2.1. Study Design and Participants

Facility based cross-sectional study was conducted consecutively on adult people living with HIV/AIDS at ART care clinic in Felege Hiwot Referral Hospital, Bahir Dar, North West Ethiopia. Ethical approval was obtained from Bahir Dar University and informed consent was obtained from the study participants.

2.2. Blood Collection and Serum Separation

After an overnight fasting, ten milliliter of blood sample was drawn from each participant using a vacuum tube system. From this amount 5ml of blood was dispensed and mixed with a labeled Ethylene Diamine Tetra Acetic Acid (EDTA) coated test tube for CD4/CD8 T-cell count and haemoglobin determination. The remaining 5ml of blood was collected with labeled plain test tube and immediately after 30 minutes of collection sera were separated by centrifugation at 3000 revolution per minute for 5 minutes then aliquot into labeled nunc tube. The aliquot was protected from light, and stored at -70°C until analysis for serum trace elements.

2.3. Immuno-Hematological Analysis

CD4+ T-cell and CD8+ T-cell count were analyzed on FACScan flow cytometer (Becton Dickinson Immunocytometry Systems, San Jose, California) with the method as described by Tsegaye, et al. [14]. Hemoglobin was determined by using HemoCue 301 analyzer (Sweden) following the procedure described by Gillet et al [15].

For this study, normal reference range for CD8+ T-cell count for male and female were 318-1891/µl and 273-1418/µl respectively, CD4:CD8 T-cell ratio for male and female were 0.4-2.1 and 0.6-2.7 respectively and anemic based on hemoglobin value for male and female were <14gm/dl and <13gm/dl respectively, all references were based on the immuno-hematological reference ranges for

adult Ethiopians [14]. Based on CD4 T-cell count there are four proposed immunological HIV-related immunodeficiency classification outlines; no significant immunodeficiency (≥500 CD4 T cells /µl), mild immunodeficiency (350-499 CD4 T-cells /µl), advanced immunodeficiency (200-349 CD4 T-cells /µl) and severe immunodeficiency (<200 CD4 T-cells /µl) [16].

All immuno-hematological analytical procedure was done at Felege Hiwot Referral Hospital.

2.4. Biochemical Analyses

The frozen serum samples were kept on dry ice and transported to Addis Ababa. Serum concentration of Zn was measured using fully automated flame atomic absorption spectrophotometer version 2006 (PG-990, London, England), following the procedure described by Mahajan et al. [17]. The measurements were done at JIJE Analytical Testing Service Laboratory (JATSL), Addis Ababa, Ethiopia. For this study, deficiency of serum zinc was defined at their serum levels less than 70µg/dl [18].

2.5. Anthropometric Measurements

Anthropometric measurements (Height, weight, upper mid arm, waist and hip circumference) were done in triplicate and the mean value was recorded. Weight and height were measured with minimal clothing and without shoe to the nearest 0·1 kg and 1mm respectively. BMI (kg/m^2) was calculated for each participant. A cut off point less than 18.5 was used to define under nourished and a BMI of 25 or above indicate overweight or obesity [19].

2.6. Data Analysis

Information recorded in the questionnaire and laboratory was entered and analyzed using SPSS (Chicago, IL, USA) software, version 16. The descriptive data were analyzed with means and standard deviations, frequency counts and percentages. Cross tabulations were carried out to compare frequencies of individual characteristics and logistic regression analysis was applied to test the strength of the association between independent and dependent variables. Any variable with a significant bivariate test at P-value less than or equal to 0.2 was selected as a candidate for the multivariate analysis and backward step wise elimination model was applied [20]. Values were considered significant when P-value is less than 0.05.

2.7. Data Quality Assurance

Standard questionnaire was used and data was collected by trained clinician with regular monitoring by the investigator. Laboratory internal quality control was monitored during the procedure and all the measurements were carried out by the same team. All glassware and bottles for blood collection, separation of serum and further analysis were used after soaked and then rinsed them with 10% nitric acid and de-ionized water respectively. Contamination tests for Zn were carried out in between10 participants. Training

and procedures was given for data collectors.

2.8. Ethical Considerations

Before data collection, ethical approval was obtained from the board of Bahir Dar University. Permission was obtained from Amhara Regional Health Bureau and from Felege Hiwot Referral Hospital administrators. Written informed consent was obtained from the study participants after the purpose of the study was explained. Participants were informed that all the data obtained from them would be kept confidential using codes instead of any personal identifiers

3. Result

3.1. Socio-Demographic and Clinical Characteristics of Study Participants

Table 1. Socio-demographic and clinical characteristics of study participants in Felege Hiwot Referral Hospital, Bahir Dar from January to February, 2013.

Characteristics	ART status N (%)		Total N (%)
	Pre-ART	On-ART	
Sex			
Male	26(50.0)	26(50.0)	52(34.7)
Female	49(50.0)	49(50.0)	98(65.3)
Age			
18-28	20(55.6)	16(44.4)	36(24.0)
29-39	34(50.7)	33(49.3)	67(44.7)
40-50	16(45.7)	19(54.3)	35(23.3)
51-60	5(41.7)	7(58.3)	12(8.0)
Residence			
Urban	56(45.9)	66(54.1)	122(81.3)
Rural	19(67.9)	9(32.1)	28(18.7)
Educational status			
Illiterate	34(61.8)	21(38.2)	55(36.7)
Primary	16(50.0)	16(50.0)	32(21.3)
Secondary	19(41.3)	27(58.7)	46(30.7)
Tertiary	6(35.3)	11(64.7)	17(11.3)
Occupational status			
Unemployed	12(52.2)	11(47.8)	23(15.3)
Casual Laborer	9(56.2)	7(43.8)	16(10.7)
Farmer	8(100.0)	0(0.0)	8 (5.3)
Student	2(50.0)	2(50.0)	4 (2.7)
Private employee	30(46.9)	34(53.1)	64(42.7)
Government employee	14(40.0)	21(60.0)	35(23.3)
CD4+T-cell count/µl			
>500	18(50.0)	18(50.0)	36(24.0)
350-500	20(52.6)	18(47.4)	38(25.3)
200-349	18(45.0)	22(55.0)	40(26.7)
<200	19(52.8)	17(47.2)	36(24.0)
CD4:CD8 T-cell count ratio			
Normal	12(35.3)	22(64.7)	34(22.7)
Abnormal	63(54.3)	53(45.7)	116(77.3)
BMI (Body Mass Index)			
Nourished	58(50.4)	57(49.6)	115(76.6)
Under nourished	13(46.4)	15(53.6)	28(18.7)
Obese	4(57.1)	3(42.9)	7(4.7)
Hgb (Hemoglobin)			
Normal	54(47.8)	59(52.2)	113(75.3)
Anemic	21(56.8)	16(43.2)	37(24.7)

From a total number of study participants, 98 (65.3 %) were females from these 49 (50%) were pre-ART. Mean age of study participants were 36 ± 8.8 years ranging from 18 to 60 years old. According to the anti-retroviral therapy status, 75 (50%) of the study participants had started ART more than a year ago. Regarding to the BMI analysis, 28 (18.7%) of the study participants had a BMI of lower than 18.5 and showed signs of under nourishment from these 15 (53.6%) were on-ART (Table 1)

3.2. Distributions of Low Serum Zinc Concentration Based on Socio-Demographic and Clinical Characteristics

The overall mean value of serum zinc concentration of study participants was 88.7± 31.84 ranging from 19 to 269 µg /dl. Based on cutoff points of low serum zinc concentration (<70 µg/dl), it was found that 46 (30.7%) participants had low serum zinc concentration.

Higher serum zinc concentration was found in female than male study participants with the mean of 90.7± 32.7 and 84.9± 30 µg /dl respectively. According to the age category, most proportion 27/67 (40.3%) of study participants with the age of 29-39 years old had low serum zinc concentration. Low serum zinc concentration was found in 23/55 (41.8%) of illiterate study participants while 4/17 (23.5%) was found in tertiary level educated.

The mean serum zinc concentration of study participants who had a CD4+ T-cell count >500 cells/µl was higher 96.08±32.8 µg/dl than in those study participants who had a CD4+ T-cell count < 200 cells/µl with the mean of 85.06±29 µg/dl. Low serum zinc concentration was observed in 11/36 (30.6%) of those study participants who had a CD4+ T-cell count < 200 cells/µl from these 9/11 (81.8%) were found in pre-ART while low serum zinc in a CD4+ T-cell count >500 cells/µl was 9/36 (25%) from these 7/9 (77.8%) were from pre-ART.

The mean serum zinc concentration of study participants who had a normal CD4:CD8+T-cell count ratio was higher (95.76±32.03µg/dl) than in an abnormal CD4:CD8+T-cell count ratio with the mean of 86.63±31.62µg/dl. Low serum zinc concentration was found in 38/116 (32.8%) of study participants who had abnormal CD4:CD8+T-cell count ratio from these 31/38 (81.6%) were per-ART while Low serum zinc concentration of normal CD4:CD8+T-cell count ratio was found in 8/34 (23.5%) from these 6/8 (75.0%) were on-ART.

Low serum zinc concentration was observed in 15/37(40.5%) of anemic study participants, of this 12/15 (80.0%) were pre-ART. The mean serum zinc concentration of study participants with hemoglobin value anemic were lower (77.73±24.99) than those study participants with normal hemoglobin value (92.29± 33.09) (Table 2).

On-ART study participants were significantly higher mean serum zinc concentration (98.43±32.47µg/dl) compared to pre-ART (78.97±28.20 µg/dl). But proportion of low serum zinc concentration was higher in 33/75 (44%) pre-ART study participants than on-ART in 13/75 (17.3%) (Figure1).

Table 2. The distribution of serum zinc concentration by socio-demographic and clinical characteristics in Felege Hiwot Hospital, Bahir Dar from January to February, 2013.

| Characteristics	Serum zinc status N (%)	
	≥70 µg/dl	<70 µg/dl
Sex		
Male	35 (67.3)	17 (32.7)
Female	69 (70.4)	29(29.6)
Age		
18-28	29 (80.6)	7 (19.4)
29-39	40 (59.7)	27 (40.3)
40-50	25 (71.4)	10 (28.6)
51-60	10 (83.3)	2 (16.7)
Residence		
Urban	84 (68.9)	38 (31.1)
Rural	20 (71.4)	8 (28.6)
Educational status		
Illiterate	32 (58.2)	23 (41.8)
Primary	25 (78.1)	7 (21.9)
Secondary	34 (73.9)	12 (26.1)
Tertiary	13 (76.5)	4 (23.5)
Occupational status		
Unemployed	17 (73.9)	6 (26.1)
Casual Laborer	9 (56.2)	7 (43.8)
Farmer	2 (25.0)	6 (75.0)
Student	2 (50.0)	2 (50.0)
Private employee	47 (73.4)	17 (26.6)
Government employee	27 (77.1)	8 (22.9)
Physical exercise		
No	66 (65.3)	35 (34.7)
Yes	38 (77.6)	11 (22.4)
ART status		
Pre ART	42 (56.00)	33 (44.00)
On ART	62 (82.70)	13 (17.30)
CD4 T-cell count/µl		
>500	27 (75.00)	9 (25.00)
350-500	22 (57.90)	16 (42.10)
200-349	30 (75.00)	10 (25.00)
<200	25 (69.40)	11 (30.60)
CD4:CD8 T-cell count ratio		
Normal	26 (76.50)	8 (23.50)
Abnormal	78 (67.20)	38 (32.80)
Hgb		
Normal	82 (72.60)	31 (27.40)
Anemic	22 (59.50)	15 (40.50)
BMI		
Nourished	84 (73.00)	31 (27.00)
Malnourished	16 (57.10)	12 (42.90)
Obese	4 (57.10)	3 (42.90)
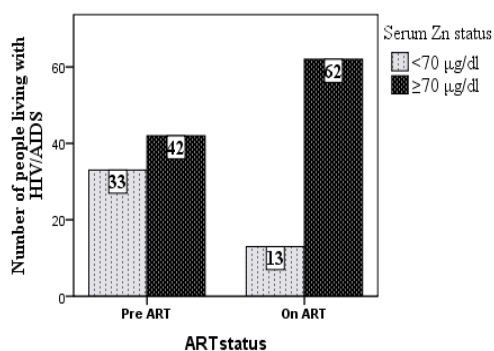
Figure 1. The distribution of low serum zinc concentration with reference to ART status of study participants in Felege Hiwot Referral Hospital, Bahir Dar, Ethiopia from January to February, 2013 (n = 150).

The overall percentage of low serum zinc concentration among combinations ARV drugs were found 13/75 (17.3%) from these the majority 5/13 (38.4%) was found in participants who were receiving AZT-3TC-NVP (Figure 2).
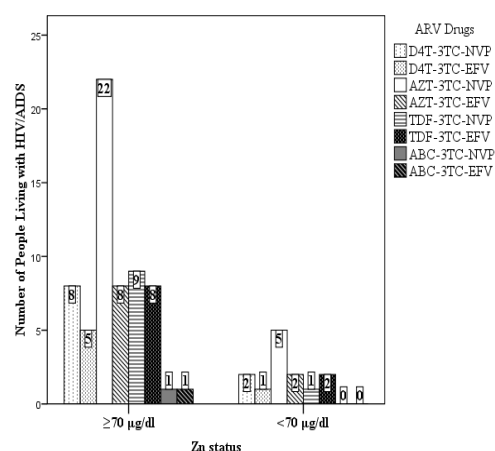

Figure 2. The distribution of low serum zinc concentration with reference to ARV drugs of study participants in Felege Hiwot Referral Hospital, Bahir Dar from January to February, 2013 (n = 150).

Based on the BMI of study participants, 12/28 (42.9%) of low serum zinc concentration were observed in under nourished study participants from these 8/12 (66.6%) were pre-ART. Low serum zinc concentration was found also in 31/115 (27%) of nourished study participants, of these 22/31 (70.9%) were pre-ART. The mean serum zinc concentration of study participants with a BMI of under nourished were lower 78.46±22.55 than in those study participants with a BMI of well nourished 91.69 ± 33.04 (Figure 3).
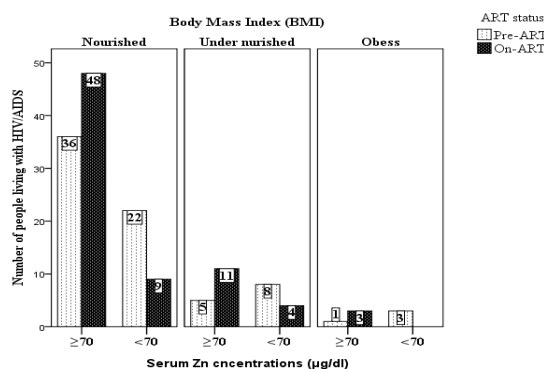

Figure 3. The distribution of low serum zinc concentration with reference to Body Mass Index (BMI) and ART status of study participants in Felege Hiwot Referral Hospital, Bahir Dar from January to February, 2013 (n = 150).

3.3. Logistic Regression Analysis of Variables Associated With Low Serum Zinc Concentration

Two factors were the strongest predictor of low serum zinc concentration. The odds ratio of being low serum zinc concentration by pre-ART study participants were more likely at risk of low serum zinc concentration than those on-ART study participants (AOR=3.56, 95% CI=1.52-8.33 p= 0.003). Similarly, the odds ratio of being low serum zinc

concentration by under nourished study participants were more likely at risk of low serum zinc concentration than those nourished study participants (AOR=2.61, 95% CI=1.02 - 6.67 p= 0.046). Regression analyses of age, educational status, occupational status, CD4 T cell count/μl and Hgb (hemoglobin) as independent variables and low serum zinc concentration as dependent variable did not show any significant association at 95% CI (Table 3).

Table 3. Logistic regression analysis of selected socio-demographic and clinical variables associated with the distribution of low serum zinc concentration in Felege Hiwot Referral Hospital, Bahir Dar from January to February, 2013) (N = 150).

Characteristics	Serum Zinc status N (%)		OR[95% CI]		P-value
	≥70 μg/dl	<70 μg/dl	COR	AOR	
Age					
18-28	29 (80.6)	7 (19.4)	1.00*	1.00*	
29-39	40 (59.7)	27 (40.3)	2.79 [1.07 - 7.29]	3.52 [1.13 - 10.91]	0.029
40-50	25 (71.4)	10 (28.6)	1.66 [0.55 - 4.99]	2.11 [0.60 - 7.38]	0.241
51-60	10 (83.3)	2 (16.7)	0.83 [0.15 - 4.66]	1.13 [0.18 - 7.13]	0.891
Educational status					
Illiterate	32 (58.2)	23 (41.8)	2.33 [0.67 - 8.09]	1.32 [0.201 - 8.74]	0.77
Primary	25 (78.1)	7 (21.9)	0.91 [0.22 - 3.69]	0.51 [0.067 - 3.91]	0.52
Secondary	34 (73.9)	12 (26.1)	1.15 [0.313 - 4.21]	0.81 [0.156 - 4.19]	0.801
Tertiary	13 (76.5)	4 (23.5)	1.00*	1.00*	
Occupation					
Unemployed	17 (73.9)	6 (26.1)	1.19 [0.35 - 4.03]	1.12 [0.24 - 5.27]	0.886
Causal laborer	9 (56.2)	7 (43.8)	2.62 [0.74 - 9.29]	2.16 [0.47 - 9.94]	0.324
Farmer	2 (25.0)	6 (75.0)	10.12 [1.70 - 60.29]	6.31 [0.72 - 55.55]	0.097
Student	2 (50.0)	2 (50.0)	3.37 [0.41 - 27.92]	7.84 [0.69 - 89.07]	0.097
Private employed	47 (73.4)	17 (26.6)	1.22 [0.46 - 3.20]	1.19 [0.38 - 3.73]	0.767
Government employed	27 (77.1)	8 (22.9)	1.00*	1.00*	
ART status					
Pre-ART	42 (56.0)	33 (44.0)	3.75 [1.77 - 7.95] ℧	3.56 [1.52 - 8.33]	0.003 Φ
On-ART	62 (82.7)	13 (17.3)	1.00*	1.00*	
CD4 T-cell count/μl					
>500	27 (75.0)	9 (25.0)	1.00*	1.00*	
350-500	22 (57.9)	16 (42.1)	2.18 [0.81 - 5.88]	3.18 [0.88 - 11.41]	0.076
200-349	30 (75.0)	10 (25.0)	1.00 [0.35 - 2.83]	1.64 [0.42 - 6.36]	0.477
<200	25 (69.4)	11 (30.6)	1.32 [0.47 - 3.72]	1.17 [0.32 - 4.24]	0.813
BMI					
Nourished	84 (73.0)	31 (27.0)	1.00*	1.00*	
Under nourished	16 (57.1)	12 (42.9)	2.03 [0.86 - 4.77]	2.61 [1.02 - 6.67]	0.046 Φ
Obese	4 (57.1)	3 (42.9)	2.03 [0.43 - 9.60]	1.98 [0.37 - 10.64]	0.425
Hemoglobin (Hgb)					
Normal	82 (72.6)	31 (27.4)	1.00*	1.00*	
Anemic	22 (59.5)	15 (40.5)	1.80 [0.83 - 3.92]	2.11 [0.82 - 5.40]	0.119

*-reference category for independent variable, ℧ -statistically significant at COR, Φ- statistically significant at AOR (p ≤0.05)

4. Discussion

Serum and plasma measurements of trace elements, which are indicators of body stores, have shown that deficiencies are common among HIV infected persons. The depletion of trace elements may occur through increased metabolic requirements, enhanced excretion, and intestinal mal-absorption [7]. The current study was hypothesized that significant lower serums zinc concentration and higher HIV disease progression among pre-ART than on-ART PLWHA.

The overall low serum zinc (< 70 μg/dL) concentration of the current study was 30.70% which is higher than the study conducted in Argentina 23% [21]; it was lower than previous findings in Iran 65% [22], in USA, Boston 42% [11], South Africa 45% [23], in Addis Ababa 53.6% [24] Gondar 69.7% [25]. Selecting different cut off points for determining low serum zinc concentration could be a reason for this variation. Other reasons could be variation in study area, commencement of ART and intake of dietary item and frequency.

In the current study, the proportion of serum zinc deficiency was higher (44%) in pre-ART study participants than 17.3% in on-ART. In accordance to the present study a study in Uganda serum zinc deficiency was higher in 59.6% of pre-ART than in 29.5% of on-ART [26]. In contrast to this, a study in Germany showed that a similar distribution of low serum zinc concentration was identified in 25% and 22% of on-ART and pre-ART respectively [10]. Similarly a study in India showed that low zinc concentration was found pre-ART and on-ART which resulted in a 50% deficiency in both groups [27].

In the current study, the mean serum zinc concentration of study participants who had a CD4+ T-cell count < 200 cells/μl was lower (85.06±29.00μg/dl) than 96.08±32.804μg/dl in those study participants who had a CD4+ T-cell count>500 cells/μl. This finding is in accordance with the study in India with the mean 83.12±12.29 μg/dl and 106.68±4.11 μg/dl of CD4 T-cells

count < 200/ μl and CD4 cell count >500 cell/ μl respectively [29]. In the current study, 30.6% of low serum zinc concentration was observed in those study participants who had a CD4+ T-cell count < 200 cells/μg while 25% of low serum zinc concentration were observed in those group who had a CD4+ T-cell count >500 cells/μl. This finding is in agreement with a study in India which revealed that a lower serum Zn level was found in patients with CD4 cells count < 200/ μl than with >500 cells / μl [28].

In the present study, low serum zinc concentration was higher in (42.9 %) of under nourished study participants than 27 % in nourished study participants. This study was in agreement with a study in Iran found that higher (41.7 %) in under nourished study participants than 33.6 % in nourished study participants [22].

In logistic regression analysis, the finding of this study revealed that, pre-ART study participants were more likely at risk of low serum zinc concentration than those on-ART study participants (AOR=3.56, 95% CI=1.52 - 8.33 p= 0.003). The differences might be due to the role of combination therapy with ARVs that reduces viral replication, pro-oxidants and cytokines. This study is in accordance with a study in Uganda which showed that pre-ART study participants were more likely at risk of low serum zinc concentration than those on-ART study participants (AOR=3.7, 95% CI=1.8 - 7.7) [26].

In the current study CD4+ T cell count had no association with zinc status. This finding is similar to what was reported in India [26]. BMI status was one of clinical determinant for low serum zinc concentration, under nourished study participants were significantly and more likely at a risk of low serum zinc concentration than nourished study participants (AOR=2.61, 95% CI=1.02-6.67, p= 0.046). This association was also reported in previous studies in South Africa (AOR=1.19, 95% CI=1.09 - 1.30, p < 0.05) [23].

Most of the socio-demographic features in the present study were not statistically significant as predictors for the deficiency of serum zinc among people living with HIV/AIDS at 95% CI. Demographic variables such as sex, residence location, marital status, monthly income and level of education were not implicated as determinants for serum zinc deficiency among the study participants. This similar finding has been reported by Visser *et al.,* (2003), Diaz Romero et al., (2002) [23,29].

5. Conclusion

The percentages of overall serum Zn deficiency indicated that PLWHA are likely to have abnormal micronutrient concentrations. Being HIV positive may lead to the depletion of Zn serum concentrations which are in turn associated with disease progression.

ART status of the study participants was identified as one of the clinical factors that had a significant association with low serum Zn concentrations as was indicated by the multiple logistic regression analysis. Those PLWHA and are on ART are less likely to have low serum Zn concentration than those who are not on ART. Body mass index were also found to be important predictors of low serum Zn concentration. Those PLWHA who are undernourished were likely to have low serum Zn concentration than those who are nourished.

Based on the major findings of the study, the following recommendations were made. Early evaluation of biochemical analyses for serum zinc deficiency should be carried out. Regular health education and counseling about maintain adequate healthy diet should be applied to PLWHA especially for those pre ART PLWHA. Providing appropriate mineral supplementation along with anti-retroviral treatment may be required especially for those who are in pre-ART and under nourished groups living with HIV/AIDS. To determine the other causes of serum zinc deficiency, a cohort study should be conducted among people living with HIV/AIDS.

Acknowledgements

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