

## Review Article

# Under Nutrition and Its Determinants Among Adults Receiving Antiretroviral Therapy in Ethiopia: A Systematic Review and Meta-analysis

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**Abstract:** Under nutrition and human immune deficiency virus/HIV have a vicious cycle. This study aimed to assess the pooled prevalence of under nutrition and determinants among adults receiving antiretroviral therapy in Ethiopia. Google scholar, PubMed, Cochrane library and web of science data bases were searched. Studies were assessed using risk of bias assessment tool. The heterogeneity of study was assessed using I<sup>2</sup> test statistics. Data were pooled and a random effect meta-analysis model was fitted to provide the prevalence of under nutrition. Twenty-one studies that satisfy the eligibility criteria were included. The pooled prevalence of under nutrition among adults receiving ART was 27.4% (95% CI: 24.4-31.4). The pooled analysis showed that lack of RUTF was more likely to lead to under nutrition [AOR=2.34 (95%CI: 1.85- 3.85)]. Also under nutrition was more likely among adults receiving ART with WHO clinical stage four [AOR=2.01 (95%CI: 1.91- 3.82)]. The pooled prevalence of under nutrition was high and Lack of RUTF as well as WHO clinical stage 4 showed significant associations with under nutrition. This finding has implication to develop policy to improve under nutrition and to continue RUTF supplement program as an integral part of HIV/AIDS continuum of care.

**Keywords:** Under Nutrition, Determinants, and ART User

## 1. Introduction

Under nutrition is a serious problem especially among HIV positive clients receiving antiretroviral therapy. Micronutrient deficiencies may also increase viral load in the blood and affect immune functions. HIV infection in nutritionally deprived individuals intensifies the nutritional deficits and further enhances cellular oxidative stress. This affects the functions of transcription factors as NF- $\kappa$ B and contributes to HIV replication and progression and malnutrition could hasten the development of AIDS in an HIV-infected person [41].

Malnutrition is considered to be the most common cause of immunodeficiency worldwide [31]. Malnutrition, immune system, and infectious diseases are interlocked in a complex negative cascade [29]. Every type of immunological deficiency induced by malnutrition can be included under the NAIDS umbrella. Malnutrition and HIV form a vicious cycle and ultimately aim at reducing the immunity of the patient. In both malnutrition and HIV there is reduced CD4 and CD8 T-lymphocyte numbers [32]. The world's highest HIV infection rates are found in Sub-Saharan Africa, where adult prevalence in most countries exceeds 25% [30]. A complex

and negatively reinforcing relationship exists between infection with Human Immune Deficiency Virus (HIV) and malnutrition. HIV-induced immune impairment and its resulting opportunistic infections (OIs) can lead to malnutrition and nutritional deficits, can, in turn, hasten the progression of HIV infection and reduce chances of survival. The determinants of under nutrition among patients receiving antiretroviral therapy are poorly understood in Ethiopia, despite a high prevalence of food-insecurity that overlaps with a generalized HIV/AIDS epidemic [8]. Therefore, this study aimed to assess under nutrition and determinants of under nutrition among adults receiving antiretroviral therapy in Ethiopia.

## 2. Material and Methods

### 2.1. Study Design and Setting

A systematic review and meta-analysis, which aimed to estimate the overall prevalence of under nutrition and its determinants was conducted in Ethiopia.

### 2.2. Eligibility Criteria

Studies were selected by considering, if conducted in Ethiopia [2], reported in English Language [3], only involved clients on ART [4], reported under nutrition and its determinants [5] and published or unpublished [3].

### 2.3. Search Methods

Search was done exhaustively by 4 (TM, DD, TM and LG) authors. Both published and unpublished articles were searched from Google scholar, PubMed, Science direct, web of science, Cochrane library and National electronic data bases. Articles were searched using both full title (under nutrition and determinants among adult clients on antiretroviral therapy in Ethiopia) and key words (under nutrition, determinants, clients on ART, Ethiopia). And then all studies were imported in to End Note reference management software. Each of the original studies was assessed using tool for assessing risk of bias. The heterogeneity of study was assessed using  $i^2$  test statistics. Data were pooled and a random effect meta-analysis model was fitted to provide the prevalence of under nutrition and its determinants among clients using ART in Ethiopia.

### 2.4. Out Come Measures

Under nutrition and determinants was the outcome of this study. All data were extracted independently by 4 (TM, DD, TM and LG) authors. Deviation in data extraction was resolved by discussion.

### 2.5. Quality Assessment for Studies

Authors assessed the risk of bias for included studies using the tool of risk of bias assessment for observational studies. This tool includes 10 items. The first 4 items assess external validity while the rest 6 internal validity. All items of the tool were categorized as low risk of bias, higher risk and not clear. The quality of the study was determined by summing the score given for each item. The summary assessment risk of bias for each study was categorized according to the number of high risk of bias: low ( $\geq 2$ ), moderate (3–4), and high ( $\geq 5$ ) [3].

### 2.6. Data Processing and Analysis

After extraction data were exported to R statistical software for meta-analysis. The double arcsine was applied to estimate the weighted average prevalence. Consistency of studies was checked via  $I^2$  test. A random effect meta-analysis was performed and subgroup analyses were conducted.

## 3. Results

### 3.1. Search Results

The study was conducted in 14<sup>th</sup> March to 30<sup>th</sup> April 2020. The flow chart diagram is under figure 1. Three hundred nineteen (319) studies were searched, then 6 were excluded due to duplication, 292 does not fulfill the criteria and 21 were included in this systematic review since met the criteria.

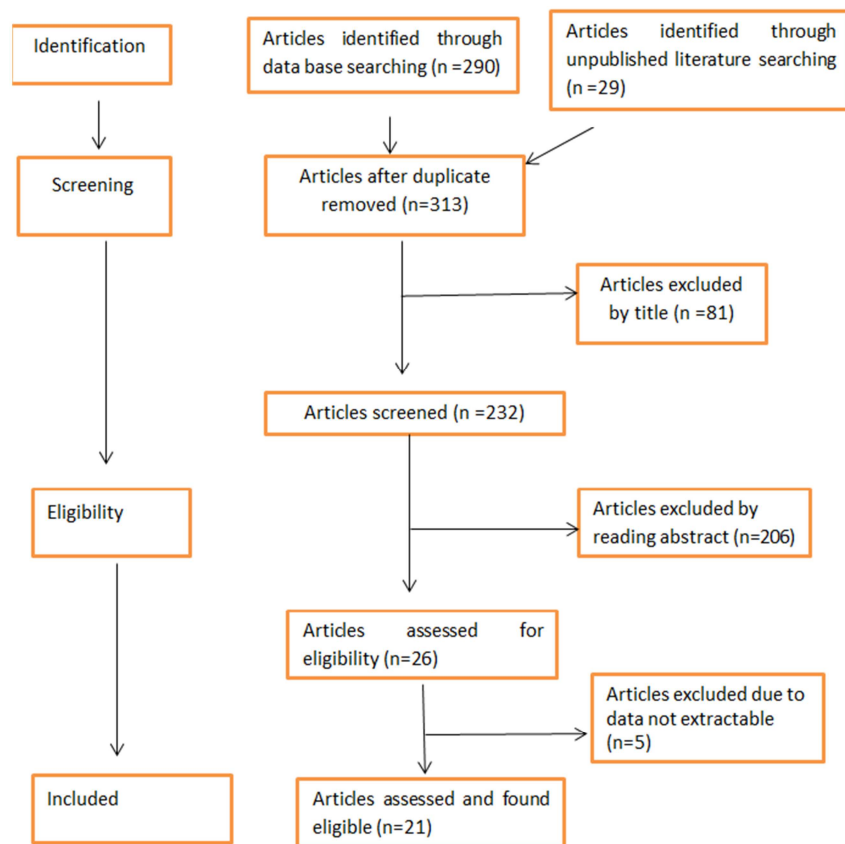
### 3.2. Description of Included Studies

Description was in table 1 below. It includes studies between 2009 and 2020 and respondents were clients on ART. The number of each study participants varied from lowest (234) to highest (1062). Furthermore, 9 studies conducted in SNNP region followed by 8 in Oromiya, 3 in Amhara, 2 in AA and 1 in Tigray. More over under nutrition ranged from 12.3 (lowest prevalence) [35] to 43 (highest prevalence) [2] (Figure 1).

**Table 1.** Descriptive summary of 21 studies on under nutrition among adults on ART in Ethiopia, 2009 – 2020.

Author (publication year)	Study year	Design	Study setting	Study population	Sample size	Prevalence of Under Nutrition
Kenea et al (2020)	2013	IBCS	Nekemte Hospital	ART Users	423	27%
Asnakew et al (2015)	2014	IBCS	Health Facilities of Hosahanna Town	Adults on ART	340	31.2%
Zemedet et al (2019)	2017	IBCS	ART clinics in the Arba Minch area	Adults on ART	351	18.23%
Saliya et al (2018)	2015	IBCS	Health Centers of Siltie Zone	people on ART	428	24.1%
H/mariam et al (2013)	2012	IBCS	Dilla University referral hospital	Adult on ART	520	12.3%
Oumer et al (2019)	2018	IBCS	Public health facilities of Arba Minchi Town	Adult on ART	333	23.72%
Shiferaw et al (2017)	2016	IBCS	Nigist Elleni Mohammed Memorial Hospital	Adult on ART	234	32.5%
Amza et al (2017)	2015	IBCS	Wolaita Sodo Teaching & referral Hospital	Adults on ART	519	26.6%

Author (publication year)	Study year	Design	Study setting	Study population	Sample size	Prevalence of Under Nutrition
Daniel et al (2013)	2009	IBCS	Felege Hiwot Referral Hospital	Adult on ART	408	25.5%
Mitiku et al (2016)	2015	IBCS	Dembia District	Adults living with HIV	452	23.2%
G/Mikael et al (2018)	2016	IBCS	Public Health Facilities in West Shewa Zone	People on ART	505	23.5%
Daka et al (2019)	2016	IBCS	Jimma Medical Center	Adult on ART	971	36.8%
Teshome et al (2020)	2017	IBCS	Chiro Zonal Hospital	Adult on ART	279	22.2%
Gedle et al (2015)	2014	IBCS	Butajira Hospital	Adult on ART	305	25.2%
Dedha et al (2017)	2016	IBCS	Four Hospitals in East Hararge Zone	Adult on ART	437	30%
Hadgu et al (2013)	2013	IBCS	Humera Hospital	Women on ART	376	42.3%
Behailu et al (2018)	2018	IBCS	Health Centers of Addis Ababa	Women on ART	342	34.2%
Gizaw et al (2018)	2017	IBCS	Jimma Town	Adult on ART	337	43%
Daka et al (2020)	2016	IBCS	Jima Medical Center	Adult on ART	1062	34%
Adal et al (2018)	2013	IBCS	Hospitals in Addis Ababa	Adult on ART	594	15.1%
Gedle et al (2017)	2015	IBCS	Butajira Hospital	Adult on ART	323	25.4%



**Figure 1.** Flow chart diagram describing the selection of studies included in this systematic review and meta-analysis, 2009 – 2020.

**Table 2.** Descriptive summary of determinants among adults on ART in Ethiopia included for meta-analysis, 2009 – 2020.

Author (Pub. year)	Determinants, AOR (95%CI)	Author (Pub. year)	Determinants, AOR (95%CI)
[23]	ART Interruption, 0.54 (0.30, 0.98)	[43]	CD4 <350, 2.5 (1.27-4.94)
	HH food insecurity, 2.51 (95% CI: 1.31 - 4.81)		HH food insecurity, 1.85 (1.16-2.86)
	low meal frequency, 0.29, 95% CI: 0.11 - 0.76)		Inadequate dietary diversity, 1.19 (1.08-1.75)
[5]	WHO staging four, 5.23 (95% CI: 1.42 - 19.35)	[36]	Anemia, 1.67 (1.05-2.65),
	Clinical staging three, 3.91 (95% CI: 1.57, 9.73)		Absence of nutritional support, 0.34 (0.22-0.54)
	Presence of OI, 2.62 (95% CI: 1.49 - 4.59)		
	Lack of nutritional support, 0.45 (95% CI: 0.23-0.89)		
[42]	Smoking, 6.67 (95% CI: 1.45–30.76)		WHO stage 3, 2.0 (1.33-2.97)
	WHO clinical stage 3, 3.11 (95% CI: 1.47–6.60)	[12]	WHO stage 4, 3.0 (1.74-5.07)
			CD4<200, 2.0 (1.38-2.47)
			Functional status bedridden 3.6 (1.55-8.35)

Author (Pub. year)	Determinants, AOR (95%CI)	Author (Pub. year)	Determinants, AOR (95%CI)
[24]	Lack of dietary counseling, 1.7, (95% CI: 1.05, 2.78) ambulatory functional status, 3.4 (95% CI: 1.67, 6.98) Unemployed, 3.4 (1.8-5.3) WHO stage 3&4, 3.3 (1.8-6.3)	[13]	Intestinal Parasite, 2.59 (1.36-4.95)
[14]	CD4<350, 2.0 (1.8-4.2) Previous OI (TB), 2.3 (1.3-4.9) Long duration on ART, 1.8 (1.2-2.9) HH food insecurity, 5.3 (2.5-8.3)	[27]	Duration on ART>12month, 0.46 (0.22-0.96) Lack of nutritional care & support, 2.18 (1.34-3.54) Diarrhea, 1.64 (1.03-2.6) Severe food insecurity 1.59 (1.04-2.52)
[9]	Substance use 1.84 (1.09 - 3.08) Taking drug for <12 month, 1.87 (1.06, 3.30)	[15]	Rural 1.98 (1.10-3.53) Eating difficulty 2.69 (1.41-5.11) Intestinal Parasite, 2.85 (1.54-5.27) TB, 8.03 (2.02-31.9)
[34]	No nutritional support, 2.21 (1.27-3.85) Smoking Habit, 6.06 (1.12-32.8) Low base line CD4, 2.12 (1.3-3.4)	[18]	Lack of RUTF, 3.42 (1.64-7.12) WHO Clinical stage 4, 12.9 (2.49-15.25)
[22]	Having no food aid, 2.76 (1.77-4.3) Lack of formal education, 2.48 (1.48-4.17) Widowed=2.18 (1.08-4.40)	[28]	Previous OI, 3.1 (2.06-5.46) Unemployed, 3.6 (1.6-7.7)
[4]	Anemia, 3.17 (1.7-5.9) CD4<200, 6.21 (2.97-12.98)	[26]	Taking ART <12 month, 1.7 (1.04-3.78)

### 3.3. Risk of Bias Assessment

Of the total studies included, 21 (95.5%) of the studies had a low risk and 1 (4.5%) had a high risk of bias.

### 3.4. Under Nutrition and Its Determinants among Clients on ART in Ethiopia

Findings from this systematic review showed that the pooled prevalence of under nutrition among adults on Antiretroviral Therapy was 27.4% (95% CI: 24.4-31.4). The highest percentage of under nutrition (43%) was reported from Jimma Town, whereas the lowest proportion of under nutrition (12.3%) was reported from Dilla University referral hospital. Under nutrition among adults on Antiretroviral Therapy is higher in the Northern part (33.3%) as compared to Central parts of Ethiopia (27.78%) and Southern parts of Ethiopia (18.9%). Of 21 studies, seven studies [7, 42, 14, 13, 2, 12, 1] showed that WHO clinical stage 3&4 was associated with under nutrition, Five studies [2, 7, 8, 14, 17] showed that lack of RUTF was associated with under nutrition and four studies [23, 13, 43, 12] showed CD4 <350 was associated with under nutrition. Four studies, showed association between duration on ART with under nutrition. Of this 4 studies 2 Studies [27, 14] showed association between long duration on ART (>12month) and under nutrition. However, another 2 studies [9, 26] showed that association between short duration on ART (<12month) and under nutrition. Under nutrition is more likely among clients who are at clinical stage 4 (OR: 2.01, 95%CI: 1.91, 3.82). Furthermore, WHO clinical stage three and four, lack of RUTF, CD4 <350, ART Interruption, Presence of opportunistic infection like tuberculosis, lack of nutritional support, Smoking Habit, lack of formal education, Functional status bedridden, Intestinal Parasite was associated with under nutrition among clients on antiretroviral therapy (Table 2).

## 4. Discussion

This review aimed to estimate the pooled prevalence of under nutrition among adult receiving antiretroviral therapy in

Ethiopia. According to this meta-analysis, the pooled proportion of under nutrition among adults receiving antiretroviral therapy was 27.4% (95% CI: 24.4%, 31.4%). This is consistent with a national study in Tanzania [10] while, a much higher pooled proportion than some other studies. For example a study conducted Sub-Saharan Africa countries showed that the pooled proportion of under nutrition among adults receiving antiretroviral therapy was 10.3% (95% CI: 7.4%, 14.1%) [30], also it is higher as compared to study conducted in Zimbabwe 7.1% [21] and Nepal (18.3% (95%CI: 14.3%, 22.6%) [33]. The above disparities could be due to the difference in socio-demographic, socio-economic, cultural and feeding pattern-related characteristics.

The subgroup analyses showed 33.3% (95%CI: 29.1, 37.6) of under nutrition is in Northern part of Ethiopia as compared to 27.78% (95% CI: 23.58, 31.98) in Central and 18.9% (95%CI: 14.7, 23.1) in Southern parts of Ethiopia. The difference may be due factors such as life style, income, Geography (degraded land in northern while fertile land in central and southern Ethiopia). Under nutrition is more likely among clients who are at clinical stage 4 (OR: 2.01, 95%CI: 1.91, 3.82). Furthermore, WHO clinical stage three and four, lack of RUTF, CD4 <350, ART Interruption, Presence of opportunistic infection like tuberculosis, house hold food insecurity, inadequate diversified diet, low meal frequency, lack of nutritional support, Smoking Habit, lack of formal education, Functional status bedridden, Intestinal Parasite were associated with under nutrition among clients on antiretroviral therapy. In this study those clients who lack ready to use therapeutic food [AOR=2.34 (95%CI: 1.85- 3.85)] and WHO clinical stage four [AOR=2.01 (95%CI: 1.91- 3.82) were more likely to have pooled prevalence of under nutrition while the study conducted in Zimbabwe showed that those facing 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 under nutrition [21] While a study conducted in Sub-Saharan Africa showed that the pooled prevalence of HIV-related malnutrition was higher among women residing in rural areas

[30]. And a study conducted in Nepal showed that age, being male, being married, smoking, hemoglobin level and on ART duration were significantly associated with body mass index score [33].

## 5. Conclusions

Findings from this systematic review showed that the pooled prevalence of under nutrition among adults on Antiretroviral Therapy was high (27.4%). Under nutrition is more likely among clients who are at clinical stage 4. Furthermore, WHO clinical stage 3 and 4, lack of RUTF, CD4 <350, ART Interruption, Presence of opportunistic infection like tuberculosis, house hold food insecurity, inadequate diversified diet, low meal frequency, lack of nutritional support, Smoking Habit, lack of formal education, Functional status bedridden, Intestinal Parasite were associated with under nutrition among clients on antiretroviral therapy. This finding has implication for Ethiopian Federal Ministry of Health to develop policy for improving under nutrition among clients on antiretroviral therapy.

## References

- [1] Adal M, Howe R, Kassa D, Aseffa A, Petros B. Malnutrition and lipid abnormalities in antiretroviral naïve HIV-infected adults in Addis Ababa. *PLoS ONE*. 2018; V: 13 (4): <https://doi.org/10.1371/journal.pone.0195942>.
- [2] Admasu Belay Gizaw, Aklilu Eshetu and Dagmawit Birhanu. Malnutrition and Associated Factors among Adult People Living with HIV/AIDS Receiving Antiretroviral Therapy at Organization for Social Service Health Development in Jimma Town Oromia Region South West Ethiopia. *General Medicine: Open Access*. 2018; DOI: 10.4172/2327-5146.1000315.
- [3] Alene M, Yismaw L, Berelie Y, Kassie B, Yeshambel R, Assemie MA. Prevalence and determinants of unintended pregnancy in Ethiopia: A systematic review and meta-analysis of observational studies. *PLoS ONE*. 2020; V: 15 (4).
- [4] Anbesaw Mitiku, Tadesse Awoke Ayele, Mekonen Assefa and Amare Tariku. Undernutrition and associated factors among adults living with Human Immune Deficiency Virus in Dembia District, northwest Ethiopia: an institution based cross-sectional study. *Archives of Public Health*. 2016; DOI 10.1186/s13690-016-0143-y.
- [5] Anema A, Vogenthaler N, Frongillo EA, Kadiyala S, Weiser SD. Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. *Curr HIV/AIDS Rep*. 2009; vol: 6 (4): 224–31. [PubMed: 19849966].
- [6] Anema A, Zhang W, Wu Y, Elul B, Weiser SD, Hogg RS, et al. Availability of nutritional support services in HIV care and treatment sites in sub-Saharan African countries. *Public Health Nutrition*. 2012; V: 15 (5): 938–47.
- [7] (Asnakew, M., Hailu, C. and Jarso, H. Malnutrition and Associated Factors among Adult Individuals Receiving Highly Active Antiretroviral Therapy in Health Facilities of Hosanna Town, Southern Ethiopia. *Open Access Library Journal*. 2015; v: 2.
- [8] Ayenew Negessie, Dube Jara, Mekaunint Taddele and Sahai Burrowes. Determinants of undernutrition among adult patients receiving antiretroviral therapy at Debre Markos referral hospital, Northwest Ethiopia. *BMC Nutrition*. 2019; <https://doi.org/10.1186/s40795-019-0284-9>.
- [9] Bilcha Oumer, Negussie Boti, Sultan Hussen, Teklemariam Gultie. Prevalence of under nutrition and associated factors among adults receiving first-line antiretroviral treatment in public health facilities of Arba Minch town, Southern Ethiopia. *Dove Press journal: HIV/AIDS - Research and Palliative Care*. 2019; Vol: 11, 313–320.
- [10] Bruno F. Sunguya, Nzovu K. Ulenga, Hellen Siril, Sarah Puryear, Eric Aris, Expeditho Mtisi, Edith Tarimo, David P. Urassa, Wafaie Fawzi and Ferdinand Mugusi. High magnitude of under nutrition among HIV infected adults who have not started ART in Tanzania a call to include nutrition care and treatment in the test and treat model. *BMC Nutrition*. 2017; DOI 10.1186/s40795-017-0180-0.
- [11] C. O. Enwonwu. Complex interactions between malnutrition, infection and immunity: relevance to HIV/AIDS infection, *Nigerian Journal of Clinical and Biomedical Research*. 2006; vol: 1, no. 1, pp. 6–14.
- [12] Daka DW, Ergiba MS. Prevalence of malnutrition and associated factors among adult patients on antiretroviral therapy follow-up care in Jimma Medical Center, Southwest Ethiopia. *PLoS ONE*. 2020; Vol: 15 (3): e0229883. <https://doi.org/10.1371/journal.pone.0229883>.
- [13] Dawit Wolde Daka, Meskerem Seboka Ergiba. Prevalence of malnutrition and associated factors among adult patients on Antiretroviral Therapy follow up care in Jimma Medical Center, Southwest Ethiopia. 2019; medRxiv preprint doi: <https://doi.org/10.1101/19011130>.
- [14] Delelegn Yilma Gebremichael, Kokeb Tesfamariam Hadush, Ermiyas Mulu Kebede and Robel Tezera Zegeye. Food Insecurity, Nutritional Status, and Factors Associated with Malnutrition among People Living with HIV/AIDS Attending Antiretroviral Therapy at Public Health Facilities in West Shewa Zone, Central Ethiopia. *Hindawi, BioMed Research International*. 2018; p-9. <https://doi.org/10.1155/2018/1913534>.
- [15] Dereje Gedle, Baye Gelaw, Dagnachew Muluye and Molla Mesele. Prevalence of malnutrition and its associated factors among adult people living with HIV/AIDS receiving anti-retroviral therapy at Butajira Hospital, southern Ethiopia. *BMC Nutrition*. 2015; <http://www.biomedcentral.com/2055-0928/1/5>.
- [16] Dereje Gedle, Gemechu Kumera, Tewodros Eshete, Kasahun Ketema, Haweni Adugna and Fetuma Feyera. Intestinal parasitic infections and its association with under nutrition and CD4 T cell levels among HIV/AIDS patients on HAART in Butajira, Ethiopia. *Journal of Health, Population and Nutrition*. 2017; p: 2-10.
- [17] Food and Agriculture Organization of the United Nations. The state of food insecurity in the World: Undernourishment around the world in 2014 Rome. 2014. Updated; cited. Available from: <http://www.fao.org/3/a-i4030e.pdf>.
- [18] Getu Teshome and Teshome Ayalew. Prevalence of Malnutrition and its Associated Factors among Adult HIV Positive Clients on Anti-Retroviral Therapy at Chiro Zonal Hospital, West Hararghe Oromia Zone, Ethiopia. 2020; vol: 11 (2), DOI: 10.37421/jar.2020.11.805.
- [19] Ivers LC, Cullen KA, Freedberg KA, Block S, Coates J, Webb P. HIV/AIDS, under nutrition and Food Insecurity. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*. 2009; Vol: 49 (7): 1096–102.

- [20] Kelly P, Musonda R, Kafwembe E, Kaetano L, Keane E, Farthing M. Micronutrient supplementation in the AIDS diarrhoea-wasting syndrome in Zambia: a randomized controlled trial. *Journal of AIDS and Palliative Care*. 1999; vol: 13 (4): 495–500.
- [21] Kudakwashe C. Takarinda, Tsitsi Mutasa-Apollo, Bernard Madzima, Brilliant Nkomo, Ancikaria Chigumira, Mirriam Banda, Monica Muti, Anthony D. Harries and Owen Mugurung. Malnutrition status and associated factors among HIV-positive patients enrolled in ART clinics in Zimbabwe. *BMC Nutrition*. 2017; DOI 10.1186/s40795-017-0132-8.
- [22] Lula Amza, Tsegaye Demissie and Yoseph Halala. Under nutrition and associated factors among adult on highly active antiretroviral therapy in Wolaita Sodo teaching and referral hospital, southern nation's nationalities people's region, Ethiopia. 2017; vol: 9 (2), pp. 10-19.
- [23] Meskerem Alemayehu Kenea, Sileshi Garoma, Habtamu Fekadu Gemede. Assessment of Adult Nutritional Status and Associated Factors among ART users in Nekemte Referral Hospital and Health Center, East Wollega Zone, Ethiopia. *Journal of Food and Nutrition Sciences*. 2015; Vol. 3 (2), pp. 56-63.
- [24] Mewuba Shamil Saliya, Telake Azale, Atinkut Alamirrew, Dawit Jember Tesfaye. Assessment of nutritional status and its associated factors among people affected by human immune deficiency virus on antiretroviral therapy: a cross sectional study in Siltiezone, South Ethiopia. 2018; Volume 6: 6361.
- [25] M. N. Woods. Dietary recommendations for the HIV/AIDS patient, in *Nutritional Aspects of HIV Infection*, T. I. Miller and S. L. Gorbach, Eds., Oxford University Press, New York, NY, USA. 1999.
- [26] Molla Daniel, Fekadu Mazengia, Dereje Birhanu. Nutritional Status and Associated Factors among Adult HIV/AIDS Clients in Felege Hiwot Referral Hospital, Bahir Dar, Ethiopia. *Science Journal of Public Health*. 2013; Vol: 1 (1), pp. 24-31.
- [27] Mulugeta Dedha, Melake Damena, Gudina Egata, Lemma Negesa. Under nutrition and associated factors among adults human immunodeficiency virus positive on antiretroviral therapy in hospitals, East Hararge Zone, Oromia, Ethiopia. 2017; Vol: 11, Issue 5.
- [28] Mulu H, Hamza L, Alemseged F. Prevalence of malnutrition and associated factors among hospitalized patients with acquired immunodeficiency syndrome in Jimma University specialized hospital, Ethiopia. *Ethiop J Health Sci*. 2016; vol: 26 (3): 217–26.
- [29] N. S. Scrimshaw, C. E. Taylor, and J. E. Gordon. Interactions of nutrition and infection, World Health Organization, Geneva, Switzerland. 1968.
- [30] Olalekan A Uthman. Prevalence and pattern of HIV-related malnutrition among women in sub-Saharan Africa: a meta-analysis of demographic health surveys. *BMC Public Health*. 2008; doi: 10.1186/1471-2458-8-226.
- [31] R. K. Chandra. McCollum Award Lecture. Nutrition and immunity: lessons from the past and new insights into the future. *American Journal of Clinical Nutrition*, 1991; vol: 53 (5), pp. 1087–110.
- [32] R. K. Chandra. Symposium on nutrition, infection and immunity: nutrition and immunology: from the clinic to cellular biology and back again. *Proceedings of the Nutrition Society*. 1999; vol. 58 (3), pp. 681–683.
- [33] Samip Khatri, Archana Amatya and Binjwala Shrestha. Nutritional status and the associated factors among people living with HIV: an evidence from cross-sectional survey in hospital based antiretroviral therapy site in Kathmandu. *BMC Nutrition*. 2020; <https://doi.org/10.1186/s40795-020-00346-7>.
- [34] Shiferaw WG, Jegora AA, Lema L, Gebremariam BM. Under Nutrition Status and Its Determinants among Adult HIV and AIDS Clients Enrolled on Antiretroviral Therapy at Nigist Elleni Mohammed Memorial Hospital, Southern Ethiopia. *J AIDS Clin Res*. 2017; 8: 733. doi: 10.4172/2155-6113.1000733.
- [35] Solomon Hailemariam, Girma Tenkolu Bune and Henok Tadesse Ayele. Prevalence and its associated factors in People living with HIV/AIDS, in Dilla University Referral Hospital Archives of Public Health. 2013; <http://www.archpublichealth.com/content/71/1/13>.
- [36] Tsegazeab Hailu Hadgu, Walelegn Worku, Desalegn Tetemke and Hailemariam Berhe, 2013. Undernutrition among HIV positive women in Humera hospital, Tigray, Ethiopia. Antiretroviral therapy alone is not enough. *BMC Public Health*. 2013; <http://www.biomedcentral.com/1471-2458/13/943>.
- [37] World Health Organization. Energy and protein requirements, report of Joint FAO/WHO/UNU expert consultation, Technical Report Series 724, Geneva, Switzerland. 1985.
- [38] World Health Organization. Nutrient Requirements for People living with HIV/AIDS: Report of a technical consultation Geneva, Switzerland: 2003; updated; cited. Available from <http://www.who.int/nutrition/topics/hivaids/en/>.
- [39] World Health Organization. Social determinants of health: What are social determinants of health. 2012; [http://www.who.int/social\\_determinants/thecommission/finalreport/key\\_concepts/en/](http://www.who.int/social_determinants/thecommission/finalreport/key_concepts/en/).
- [40] World Health Organization. Global Tuberculosis report. Geneva, Switzerland. 2016; <http://apps.who.int/iris/bitstream/10665/250441/1/9789241565394-eng.pdf?ua=1>.
- [41] W. R. Beisel. Nutrition and immune function: overview, *Journal of Nutrition*. 1996; vol. 126 (10), pp. 2611.
- [42] Zale Zemedu, Befikadu Tariku, Mesfin Kote, Wubshet Estifanos. Under nutrition and associated factors among HIV-positive adult patients enrolled in antiretroviral therapy (ART) clinics in the Arba Minch area, southern Ethiopia, Dove Press journal of HIV/AIDS - Research and Palliative Care. 2019; Vol: 11: 147–154.
- [43] Zinet Behailu, Robel Yirgu. Malnutrition among HIV-positive pregnant women; magnitude and determinants, in health centers of Addis Ababa Ethiopia. 2018; p: 1-5.