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

Tesfa Mengie¹ *, Demeke Dejen², Temesgen Muche³, Lemma Getacher⁴

¹Amhara Regional Health Bureau, CDC Project Zonal Monitoring and Evaluation Officer, Dessie, Ethiopia
²North Wollo Zone Cluster Health Facilities HIV Case Detection, Linkage, Care & Treatment Coordinator, Woldia, Ethiopia
³School of Public Health, College of Medicine and Health Sciences, Dilla University, Dilla, Ethiopia
⁴Department of Public Health, College of Health Science Institute of Medicine and Health Science, Debre Birhan University, Debre Birhan, Ethiopia

Email address: mengie.tesfa@yahoo.com (T. Mengie)
*Corresponding author

To cite this article:
Tesfa Mengie, Demeke Dejen, Temesgen Muche, Lemma Getacher. Under Nutrition and Its Determinants Among Adults Receiving Antiretroviral Therapy in Ethiopia: A Systematic Review and Meta-analysis. International Journal of Homeopathy & Natural Medicines. Vol. 7, No. 1, 2021, pp. 1-6. doi: 10.11648/j.ijhnm.20210701.11

Received: December 17, 2020; Accepted: February 14, 2021; Published: April 26, 2021

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 I² 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-kB 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 patients 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. Outcome 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 ($>/=2$), moderate (3–4), and high ($>/=5$) [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 $F$ test. A random effect meta-analysis was performed and subgroup analyses were conducted.

3. Results

3.1. Search Results

The study was conducted in 14th March to 30th 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).

| 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 Hosannah 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 Minch 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%                        |
| Gede 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   | Jimma 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) |
| [5]                | HH food insecurity, 2.51 (95% CI: 1.31 - 4.81) | [36]               | 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) |
|                    | WHO staging four, 5.23 (95% CI: 1.42 - 19.35) |                     | CD4<200, 2.0 (1.38-2.47) |
|                    | Clinical staging three, 3.91 (95% CI: 1.57, 9.73) |                     | Functional status bedridden 3.6 (1.55-8.35) |
|                    | 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) | [12]               |                           |
|                    | WHO clinical stage 3, 3.11 (95% CI: 1.47–6.60) |                     |                           |
The prevalence of undernutrition among adults on Antiretroviral Therapy (ART) in Ethiopia 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 undernutrition 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).

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 of Ethiopia 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, 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 (Table 2).

### 4. Discussion

This review aimed to estimate the pooled prevalence of undernutrition among adult receiving antiretroviral therapy in Ethiopia. According to this meta-analysis, the pooled proportion of undernutrition 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 undernutrition 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).

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 of Ethiopia 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, 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 (Table 2).

### 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

The prevalence of undernutrition 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 of Ethiopia 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, 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 (Table 2).

### 4. Discussion

This review aimed to estimate the pooled prevalence of undernutrition 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 undernutrition 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.
5. Conclusions

Findings from this systematic review showed that the pooled prevalence of undernutrition 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): 10.1371/journal.pone.0195942.

[2] Admasu Belay Gizaw, Akilu 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 Dambia 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. Sunguaya, Nzovu K. Ulenga, Hellen Siril, Sarah Puryear, Eric Aris, Expedito Mtsi, Edith Tarimo, David P. Urassa, Wafaie Fawzi and Ferdand Magusi. 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, Dawgachew 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, Gemecu Kumera, Tweodros Esheke, Kasahun Ketema, Haweni Adugna and Fatuma 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/ZAa-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 Chipa 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, Mirrim Banda, Monica Muti, Anthony D. Harries and Owen Mugurun. 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 Gemed. 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 Shamli Saliya, Telake Azale, Atinkut Alamirrew, Dawit Jember Tesfaye. Assessment of nutritional status and its associated factors among people affected by human immunodeficiency 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. L. Miller and S. L. Gorbach, Eds., Oxford University Press, New York, NY, USA. 1999.

[26] Molla Daniel, Fekadu Mazenga, 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 Nigest 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/7/1/13.

[36] Tsegazeb Haiful Hadgu, Waleagen Worku, Desalegn Petemque 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/.

[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 Zemedo, 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.