

# Under-nutrition and associated factors among human immunodeficiency virus-infected children in sub-Saharan Africa: A systematic review and meta-analysis.

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## Systematic Review

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## Abstract

**Background:** In developing world including sub-Saharan Africa, HIV/AIDS has worsened the impact of under-nutrition in children. HIV infected children are highly vulnerable to malnutrition. Even though under-nutrition screening and intervention are incorporated into the care plan of HIV infected children, it is continued as a major problem for HIV infected children in Africa. Hence, the main aim of this systematic review and meta-analysis was to estimate the pooled prevalence of under-nutrition and associated factors among children infected with HIV.

**Methods:** Primary studies were retrieved from PubMed/ MEDLINE online, Science direct, and Hinari databases. We found a total of 1847 records from these databases. After removing papers by using different exclusion criteria, 26 studies that report the prevalence of under-nutrition were included. We used a standardized data extraction format prepared in Microsoft Excel. STATA- version 14 statistical software was used for analysis. Heterogeneity was evaluated through  $I^2$  test. A random-effects meta-analysis model was used to estimate the pooled prevalence of under-nutrition and its associated factors. The summary estimates were also presented using Forest plots and tables.

**Results:** The pooled prevalence of stunting, underweight, and wasting in HIV infected children were 51.4% (95% CI: 46.3, 56.4), 39.0% (95% CI: 33.7, 44.3), and 24.5% (95% CI: 19.2, 29.8) respectively. Household insecurity was associated with stunting [OR= 5.50 (95% CI 3.36, 8.98)]. Low family economic status [OR= 5.25 (95% CI: 2.52, 10.92)], feeding frequency [OR= 0.32 (95% CI 0.172, 0.605)] and caretakers attending dietary counseling [OR= 0.367 (95% CI: 0.182, 0.739)] were significantly associated with under-weight among HIV infected children.

**Conclusions:** The pooled prevalence of under-nutrition among HIV infected children was high. Routine nutritional assessment and nutritional support shall be strengthened, monitored, and evaluated in HIV infected children. Implementation of policies and strategy sated by a national and international stakeholder in ART care centers should get maximum emphasis to reduce undernutrition in HIV infected children.

## Background

Under-nutrition and Human immunodeficiency virus (HIV) are both highly prevalent in the world, particularly in sub-Saharan Africa [1]. Globally, nearly 2.84 million children aged 0 to 19 years in 2019 were living with HIV, more than 90% were in sub-Saharan Africa [2]. In 2018, about 49 and 149 million under-five children were stunted and wasted respectively, more than 90% were living in low and middle-income countries [3]. The Magnitude of stunting and wasting in Sub-Saharan Africa varies across the region as high as 32% and 10%, respectively [4]. HIV/AIDS, poverty, and food insecurity were the main causes for such high under-nutrition problems [5].

The risk of malnutrition was higher among HIV-infected children than non-HIV-infected children [6]. Studies have shown that stunting, under-weight, and wasting were more prevalent among HIV infected children [7-9]. More than half of children with HIV/AIDS may also be suffering from severe under-nutrition [10]. Malnutrition also increased the frequency and severity of the opportunistic infection and delayed recovery from disease in HIV infected person [9, 11].

Malnutrition is responsible for 11% of the global disease burden [12], more than 35% of child death [13], and deformities such as cognitive impairment, chronic diseases, and growth failure [13]. In a resource-limited setting, every year more than one-third of mortality in under-five children was due to malnutrition [14]. In HIV infected children the risk of death due to malnutrition is three-time higher than non-HIV infected children [15].

HIV/AIDS, Under-nutrition, and lack of essential micronutrients affect the immune system leading to a nutritionally acquired immune-dysfunction syndrome which increases susceptibility to infection and complicates case management [16-18]. Inadequate vitamins and minerals cause oxidative stress, which can cause immune cell death and increase HIV replication [19]. On the other hand, HIV infection increases the risk of malnutrition, because of a high pro-inflammatory cytokine activity which can cause growth impairment [20]. HIV-related opportunistic infections such as persistent diarrhea or oral and oesophageal candidiasis have a negative impact on nutritional status [21].

Even though under-nutrition screening and intervention are incorporated into the care plan of HIV infected children, it is continued as a major problem for HIV infected children in Africa [22]. Studies from different parts of the world reported differing magnitude of low nutritional status of HIV infected children and identified study setting-specific factors. Subsequently, reliable and summarized information is essential to reduce the nutritional problem in HIV infected children. Different independent and fragmented studies have been conducted to assess under-nutrition among HIV infected children in sub-Sahara Africa while their reports show great variation and inconsistency related to its prevalence across the different countries in the region.

Hence, the main aim of this systematic review and meta-analysis was to estimate the pooled prevalence of under-nutrition and associated factors among HIV infected children in sub-Sahara Africa. Therefore, this review can have vital importance to show summarized evidence and suggest possible applicable strategies for planning, decision making, and resource allocation in the health care system of the sub-Saharan African region.

## Methods

### Identification and selection of studies

Published and unpublished research reports describing the prevalence and associated factors of under-nutrition (stunting, wasting, and under-weight) among HIV infected children were reviewed. Relevant studies were searched from PubMed/ MEDLINE online, Science direct, and Hinari databases. Grey literature were also identified from Google and Google Scholar. All searches were conducted from May to July 30/2020. The key terms used to retrieve primary studies

were (Prevalence OR Magnitude AND under-nutrition OR, stunting OR under-weight OR wasting OR malnutrition/ AND human immunodeficiency virus (HIV) AND children AND sub-Saharan Africa). We also used key terms of ((Factors OR determinants OR risk factors OR correlates) AND under-nutrition /malnutrition/ AND human immunodeficiency virus (HIV) AND children AND sub-Saharan Africa) to search literature regarding factors associated with under-nutrition among HIV infected children. The systematic review and meta-analysis were carried out in harmony with Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline [23].

### Eligibility criteria

Observational studies including cross-sectional, comparative cross-sectional, case-control, and cohort studies with original data reporting the prevalence or/and its associated factors of undernutrition among children (aged up to 18 years) infected with HIV in sub-Saharan Africa conducted from 2010-2020 were included. In this review, we included articles published in English. Studies that did not specify the type of under-nutrition and were poor quality were excluded.

### Data extraction

We used a standardized data extraction format prepared in Microsoft Excel for each type of under-nutrition (stunting, under-weight, wasting) independently to extract all the necessary data. The extraction formats contain different columns including the name of first author, publication year, country where the study was conducted, sample size, outcome, response rate, study design, age range and prevalence of under-nutrition (stunting, underweight, wasting) for the first objective. For the second objective (factors associated with stunting, underweight, wasting), the data extraction format was prepared in the form of a two-by-two table.

### Outcome measurements

This study has mainly two objectives. The first objective was the pooled prevalence of under-nutrition among HIV infected children in sub-Saharan Africa. The second objective was the factors associated with stunting, underweight, and wasting among HIV infected children. In the included studies, the screening of stunting, under-weight, and wasting was performed through height for age Z-score (HAZ), weight for age Z-score (WAZ), and weight for height Z-score (WHZ) respectively. The outcomes were measured using the percentage of under-nutrition (stunting, under-weight, and wasting) among HIV positive children. The associated factors of under-nutrition were measured in terms of the odds ratio. The odds ratio was calculated from primary studies using two by two tables.

### Quality assessment

The quality of the included studies has been assessed by the Newcastle-Ottawa quality assessment scale [24]. The tool has three main parts. The first part had five components used to assess the methodological quality of each study. The second part assesses the comparability of primary studies, and the final part of the tool measures the quality of the original articles concerning their statistical analysis. Two authors (JN, BG) independently assessed the methodological quality, quality of reported data, stratified data on the types of patient (stunted, under-weight, and wasted), and clarity of the research design of the included studies. After assessing the quality of each included studies articles with high quality (a minimum score of 6 out of 10 scores) were included in this review.

### Statistical procedure

The extracted data from the Microsoft Excel format were exported to STATA Version 14.0 (software) for analysis. The characteristics of the original articles were described using a table as well as a forest plot. Statistical heterogeneity was evaluated by  $I^2$  test, which shows the level of heterogeneity between studies [25]. The percentage of variability due to heterogeneity rather than sampling error or chance in effect estimate was determined through the  $I^2$  test. Basically, the  $I^2$  test doesn't depend on the number of studies incorporated into the study. A Random-effect meta-analysis model was used to estimate the pooled prevalence of under-nutrition and its associated factors. The pooled effect size was conducted in the form of prevalence and odds ratio. Subgroup analysis was also done by a country, to minimize the random variations in the point estimates of the primary study. The Egger's weighted regression and Begg's rank correlation test were used to assessing publication bias at 5% significant level [26, 27].

## Result

In the initial search, we found a total of 1847 records from the electronic search database of Midline/PubMed, Science direct, Hinari, Google, and Google scholar. After removing duplication 1028 records remained. After reviewing their titles and abstracts, we were excluded 992 records due to these articles were unrelated to our objective. Then after assessing 36 full articles 10 articles were further excluded due to differences in the study population and unspecified outcome. Finally, 26 studies were included in this systematic review and meta-analysis (**figure 1**).

### Characteristics of the included articles

This meta-analysis included 26 different studies covering a total of 13,212 children aged 0 to 18 years. The studies were conducted from 2010 to 2020 among more than 14 sub-Saharan Africa countries [7-9, 19, 28-49] (**Table 1**). All of the studies included in this review were observational studies conducted in a health facility with the sample size ranging from 28 to 3195 participants as reported from a study in South Africa [44] and West Africa [41] respectively. All included studies were used WAZ, WHZ, and HAZ below -2 Z- score (WHO standard) to diagnose under-weight, wasting, and stunting respectively.

The highest prevalence of stunting was reported from a study in Cameroon 77.0% [42], and the least was from a study in Mali 20.0% [49]. Similarly, the highest prevalence of underweight was reported from a study in Nigeria 58.6% [8], and the minimum was from a study in Tanzania 6.8% [45]. The highest (52.0%) and the least (5.8%) prevalence of wasting were also reported from studies conducted in Senegalese [38] and Ethiopia [30] respectively.

## Meta-analysis

To estimate the prevalence of stunting, 26 studies were included in the analysis; the overall pooled prevalence of stunting was 51.4% (95% CI: 46.3, 56.4) (**Figure 2**). Similarly to estimate the prevalence of underweight, 24 studies were included in the analysis, the overall pooled prevalence of underweight was 39.0% (95% CI: 33.7, 44.3) (**figure 3**). Twenty-five studies were also included in the analysis to estimate the prevalence of wasting; the overall pooled prevalence of wasting was 24.5% (95% CI: 19.2, 29.8) (**figure 4**). High heterogeneity was observed between studies on the prevalence estimate of stunting as evidenced by ( $I^2= 96.9\%$  and  $p=0.000$ ). The heterogeneity of the prevalence estimates on underweight was also high ( $I^2 = 97.0\%$  and  $p=0.0000$ ). Similarly, there was also high heterogeneity of the prevalence estimate on wasting as evidenced by  $I^2= 97.1\%$  and  $P\text{-value}=0.000$ ). Publication bias was checked using the Eggers test and its result showed that there is no significant publication bias as evidenced by  $p = 0.590, 0.206,$  and  $0.197$  for stunting, underweight, and wasting respectively. We also observed the symmetrical distribution of the funnel plot indicating the absence of publication bias (**figure 5& figure 6**).

We also done subgroup analysis by the country having more than two studies conducted. According to the result, the pooled prevalence estimate of stunting was highest in Cameroon, 65.6% (95% CI: 52.8, 78.3),  $I^2 = 86.7\%$  and the least was in Nigeria, 46.0% (95% CI: 32.9, 59.0),  $I^2= 89.2$ . The highest pooled prevalence estimate of underweight in sub-group analysis was in West Africa, 55.5% (95% CI: 53.8, 57.2),  $I^2 = 0.0\%$  and the least was in Tanzania, 24.1% (95% CI: 10.9, 37.3),  $I^2 = 97.9\%$ . Similarly, the highest pooled prevalence of wasting in sub-group analysis was in West Africa studies, 39.5% (95% CI: 37.8, 41.2),  $I^2 = 0.0\%$  and lowest was in Tanzania, 15.1% (95% CI: 0.52, 29.62),  $I^2 = 98.3\%$ .

## Factors associated with under-nutrition of HIV infected children

### Factors associated with stunting

During the review of primary articles, we have identified numerous factors associated with stunting in the primary study. Variables reported as a significant association with stunting in at least three primary studies were included in this metal analysis. Accordingly, household food insecurity was found to have a significant association with stunting among HIV infected children.

#### Household food insecurity:

Household food insecurity was reported as factors associated with stunting among three primary studies included in this review [7, 32, 45]. A total of 1180 children were included to analyze the association between household food insecurity and stunting among HIV infected children. The pooled odds ratio showed that children from food-insecure households were 5.50 times more likely to have stunting as compared with their counterparts [OR= 5.50 (95% CI 3.36, 8.98)] (**Figure. 7**).

### Factors associated with under-weight

To identify factors associated with stunting, we reviewed more than 7 primary studies and identified numerous factors for the occurrence of underweight in HIV infected children in the primary study. Variables reported as a significant association with underweight in three primary studies were included in this meta-analysis. Accordingly, low family income, feeding frequency, and caretakers attending dietary counseling were significantly associated with the underweight.

#### Family economic status

Family economic status was identified as a factor associated with underweight among three primary articles included in this review [28, 30, 45]. A total of 940 participants were included to analyze the association between monthly family income and underweight among HIV infected children. The odds of developing underweight among HIV infected children who have low family economic were 6.28 times more likely to be underweight as compared with their counterparts [OR= 5.25 (95% CI: 2.52, 10.92)] (**Figure. 8**).

#### Feeding frequency

Feeding frequency was identified as a factor associated with underweight among HIV infected children in three primary studies included in the meta-analysis [7, 28, 32] with a total of 1, 381 study participants. The odds of underweight among HIV infected children who feed 4 times and more per 24 hours were 67.8 % less likely to become underweight than children feeding less than 4 times per 24 hours [OR= 0.32 (95% CI 0.172, 0.605)] (**figure 9**).

#### Child caretaker dietary counseling

Caretaker dietary counseling was identified as a factor for underweight HIV infected children in two primary studies [28, 30] with a total of 721 study participants. The pooled odds ratio showed that the risk of underweight among children whose caregivers taken dietary counseling sessions was significantly lower (64.3%) as compared to their counterpart [OR = 0.367 (95% CI: 0.182, 0.739)] (**figure 9**).

### Factors associated with wasting

In this review, we have found numerous factors associated with wasting reported from different primary studies. No variables were identified as factors for wasting in at least three primary studies. Therefore meta-analysis to identify the associated factors for wasting was not done, but some factors reported as significant association with wasting in at least two primary studies were summarized through the table as below (**Table 2**).

## Discussion

This review was conducted to show the prevalence and associated factors of under-nutrition (stunting, under-weight, and wasting) among HIV infected children in sub-Saharan African countries. There are different primary studies conducted on the prevalence of under-nutrition among children infected with HIV; however, their report shows a great discrepancy regarding the prevalence and associated factors of under-nutrition among HIV infected children. As per the knowledge of the authors, this is the first systematic review and meta-analysis in sub-Saharan Africa.

The result of this meta-analysis showed that the pooled prevalence of stunting was 51.4% (95% CI: 46.3, 56.4) among HIV infected children. The finding was in line with a study conducted in India 46.37% [50]. However, it was low as compared to a study conducted in south India 58% [51]. This might be due to the timing of the studies in which stunting was reduced in the last 10 years worldwide. It was higher than a study conducted among HIV infected adolescence (41%) in the less developed region of the world [52]. The finding was also much higher than the WHO estimate of stunting, 32.5% among children regardless of HIV status for the African region in 2019 [3]. This is expected since under-nutrition is prevalent in HIV infected children than uninfected [9].

The pooled prevalence of underweight was 39.0% (95CI: 33.7, 44.3). It was low as compared to studies conducted in southern India 65% [51] and India 55.2% [50]. The discrepancy might be due to the background rate of HIV infection and malnutrition in the area. In this meta-analysis, the pooled prevalence of wasting was 24.5% (95% CI: 19.2, 29.8). The result was higher than a study conducted in south India 16% [51]. It was also higher as compared to a study conducted in the less developed region of the world 14.5% [52] and WHO estimate of wasting 6.4% in Africa [3]. However, it was lower than another study in India 34.3% [50]. The reason for the discrepancy may be due to the sample size and study population regarding HIV status.

Regarding factors associated with under-nutrition among HIV infected children, household food insecurity was significantly associated with stunting. Low family economic status, feeding frequency, and child-caregiver have taken dietary counseling were also found significantly associated with underweight. Children living in the food-insecure household were 5.5 times more likely had stunting as compared to children living in the food-secure household. The reason might be that there may be starvations in food-insecure households which easily leads to stunting. Children whose families have low economic status were 5.25 times more likely to had under-weight compared to their counterparts. The reason might be that children's having low family economic status may be faced with poor food accessibility and a lack of a balanced diet. HIV infected children who feed 4 times and more per day were 67.8 % less likely to had under-weight than children feeding less than 4 times per 24 hours. This might be that low meal frequency and diversity demonstrates poor food accessibility and low micronutrient intake[53].

Children whose caregivers taken dietary counselling were 63.3% less likely to had underweight than children whose caregiver not taken dietary counseling. Providing dietary counseling gives important information for child caregivers regarding feeding frequency, feeding diversity, and adequate micronutrient intake for their HIV positive child.

#### **Limitation of the study**

This study analyzes the pooled prevalence and associated factors of under-nutrition among HIV infected children in multiple databases to search for meta-analysis. Since most of the primary studies included in this systematic review and meta-analysis had great disparity regarding factors associated with under-nutrition, we are not included sufficient factors associated with under-nutrition in the meta-analysis. Methodological variations among included studies could also compromise the result of the study.

## **Conclusion**

This review showed that the prevalence of underweight in HIV infected children was high. More than half of the HIV infected children become stunted and more than 25% had wasted. The review also showed that two in every five HIV infected children were under-weight. Household food insecurity was associated with the occurrence of stunting. Low family economic status, low feeding frequency, and taking dietary counseling were also associated with under-weight among HIV infected children. Nutritional assessment and interventions need a great concern as ART during the HIV care of children.

## **Declarations**

#### **Ethics approval**

Not applicable

#### **Consent for publication**

Not applicable

#### **Availability of data and materials**

The data used for this study is available here. It will be shared upon request and will be obtained by email to the corresponding author using "nigussiejemberu@gmail.com. Or jemberu2123@gmail.com".

#### **Competing interests**

All authors declare that they have no competing interests.

#### **Funding**

Not applicable

### Authors' contributions

JN and BG conceived the idea, participated in data extraction, analysis, and draft writing. AM and MM participated in the analysis, manuscript preparation, and revision. All authors read and approved the final version of the manuscript to be considered for publication.

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## Tables

**Table 1:** Summary of included studies in the systematic review and meta-analysis of prevalence and factors associated with under-nutrition among HIV infected children in Sub-Saran Africa 2020.

Author	publication year	country	Sample size	response rate	Prevalence of stunting	Prevalence of under-weight	Prevalence of wasting	Study design	Age range
Kusum Lata et.al	2020	Ethiopia	420	92.30	60.20	41.20	21.40	cross-sectional	6m-14 y
Sunguya et al	2011	Tanzania	213	100.00	36.60	22.10	13.60	Comparative cross-sectional	6m-5y
Henry Chineme et al.	2014	Nigeria:	70	100.00	48.60	58.60	31.40	Comparative cross-sectional	6m-18y
Maura Pedrini et.al	2015	Mozambique	140	93.95	57.40	47.10	18.60	cross-sectional	6m-15 y
Jesson et al.	2015	central and west Africa	1350	100.00	32.90	36.00	16.50	cross-sectional	2y-19y
Megabiaw et.al	2012	Ethiopia	301	99.34	65.00	41.70	5.80	cross-sectional	6m-14 y
Poda et al.	2017	Burkina Faso	164	95.35	29.90	11.60	10.40	Comparative cross-sectional cohort	<5y
Calixte Ida Penda et al.	2018	Cameroon	217	100.00	63.60	37.80	18.40	cross-sectional	13day-5y
Bruno F. Sunguya et al	2014	Tanzania	748	93.85	61.90	26.50	6.30	cross-sectional	6m-14 y
Andreas Chiabi et al	2012	Cameroon	39	100.00	51.30	56.40	20.50	cohort	6wk-15y
A.F. Fagbamigbe et al	2019	Nigeria:	390	100.00	36.00	50.00	50.00	cross-sectional	6y-18y
E. A. anigilaje et al	2015	Nigeria:	180	94.80	54.40	12.10	33.50	cross-sectional	6wk-5y
Teklemariam Z. et al	2015	Ethiopia	108	59.01	49.10	51.60	31.50	cross-sectional	<15y
R. S. MWIRU et al	2014	Tanzania	3144	98.86	52.00	40.00	30.00	cohort	<15y
Jesson J. et al	2018	West Africa	161	100.00	52.00	52.00	36.00	cross-sectional	<2 yr
Cames C. et al	2017	Senegalese	244	100.00	42.00		52.00	cross-sectional	2-16 yr
Ute D. Feucht. et al	2016	south Africa	159	100.00	73.00	50.00	19.00	cohort	<5 yr
Julie Jesson. et al	2019	West Africa	3195	76.90	50.20	55.70	39.70	cohort	<16 yr
Sofeu CL. et al	2019	Cameroon	210	100.00	77.00	53.00	47.60	cross-sectional	<1 yr
McHenry MS. Etal	2019	Kenya	426	100.00	50.90	26.50	13.60	cohort	<5yr
Kimani-Murage et al	2011	south Africa	28	100.00	28.60	10.70	7.00	cross-sectional	1-5yr
Sunguya et al	2012	Tanzania	219	100.00	40.10	6.80	10.00	cross-sectional	<15yr
R. Weigel et al	2010	Malawi	363	73.00	69.10	51.80		cohort	<15 yr
Tekleab AM, et al	2016	Ethiopia	202	100.00	71.30	39.50	16.30	cohort	<5YR
David Aguilera. et al	2019	Equatorial Guinea.	213	100.00	56.30	56.30	27.70	cross-sectional	<18yr
Julie Jesson. et al	2017	Mail	308	88.50	20.00		31.50	cohort	<15yr

**Table 2:** Summary of primary studies of reporting factors associated with stunting among HIV infected children in sub-Saharan Africa, 2020.

Author's name and publication year	Factor associated with stunting among HIV infected children			
	Age of the child(<5* years V <sub>S</sub> >=5 years)	WHO staging (advanced* V <sub>S</sub> not advanced)	**Food insecurity (hunger* V <sub>S</sub> not hunger)	Is Stunted at ART initiation? (Yes* V <sub>S</sub> no)
Sunguya et.al 2011		√	√	
Bruno F.Sunguya et al 2014	√	√	√	
Jesson et.al 2015	√			
R. S. M wiru et al 2014	√			√
Sunguya et al 2012			√	
Jesson J. et al 2018				√

\*Risk of stunting was higher than their counterpart. \*\*Factors included in the analysis

**Table 3:** Summary of primary studies reporting factors associated with underweight among HIV infected children in sub-saran Africa, 2020.

Author's name and publication year	Factors association with under-weight among HIV infected children							
	Sex of the child(male V <sub>S</sub> female*)	Age of the child (<2 year* V <sub>S</sub> >=2 year)	WHO staging (advanced* V <sub>S</sub> not advanced)	**Feeding frequency /24hr (<4/24* V <sub>S</sub> >=4/24)	**Family monthly income(low* V <sub>S</sub> high)	Birth weight(<2500g* V <sub>S</sub> >=2500g)	**Child Care taker takes Dietary counselling (yes V <sub>S</sub> no *)	Food security(hunger* V <sub>S</sub> not hunger)
E. A. anigilaje et al 2015	√							
Sunguya et al 2012	√				√	√		√
Kusum Lata et.al 2020			√	√	√		√	
R. S. Mwiru et al 2014		√	√					
sunguya et al 2011				√		√	√	√
M egabiaw et.al 2012		√			√		√	
B runo F. Sunguya et a l 2014				√				

\*Risk of under-weight was higher than their counterpart. \*\*Factors included in the analysis

**Table 4:** Summary of primary studies reporting factors associated with wasting among HIV infected children in sub-Saharan Africa, 2020.

Author's name and publication year	Factors association with wasting among HIV infected children					
	Age of the child (<2 year <sup>s</sup> * V <sub>S</sub> >=2 year)	WHO staging (advanced* V <sub>S</sub> not advanced)	Presence of acute disease(yes or no*)	Anemia (Yes* or No)	Severe immunosuppression(Yes* or No)	Wasting at ART initiation(Yes* or No)
Jesson et al. 2015					√	
Jesson J. et al 2018						√
Kusum Lata et.al 2020			√			
R. S. Mwiru et al 2014	√	√		√	√	√
s unguya et al 2011			√			
Julie Jesson. et al 2017				√		
B runo F. Sunguya et al 2014	√	√				

\*Risk of under-weight was higher than their counterpart.

## Figures

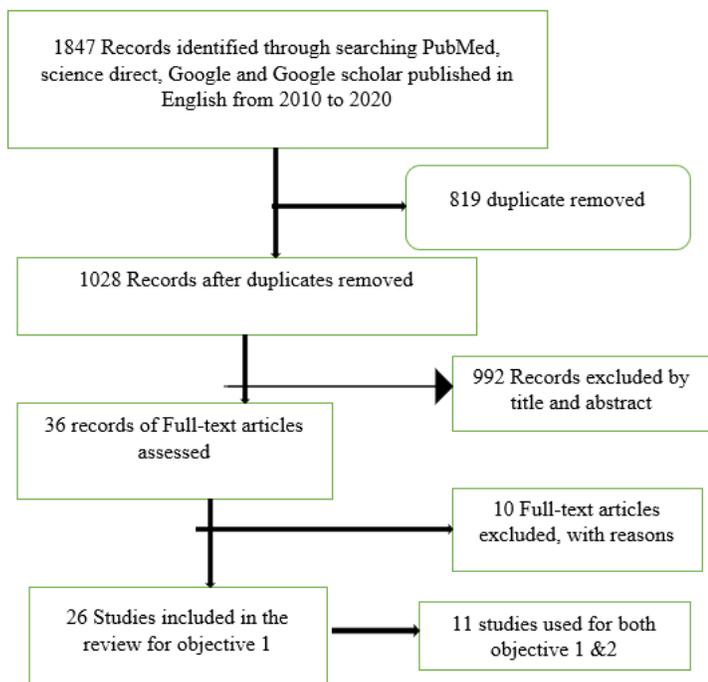


Figure 1

Flow chart of the selection process for the studies included in the analysis.

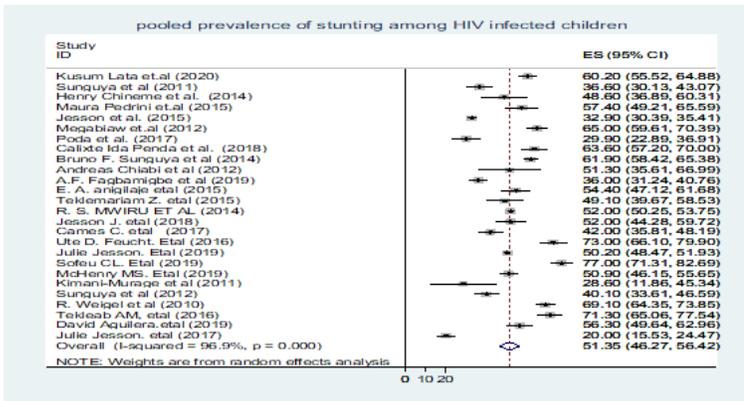


Figure 2

Forest plot for the pooled prevalence of stunting among HIV infected children in sub-saran Africa, 2020.

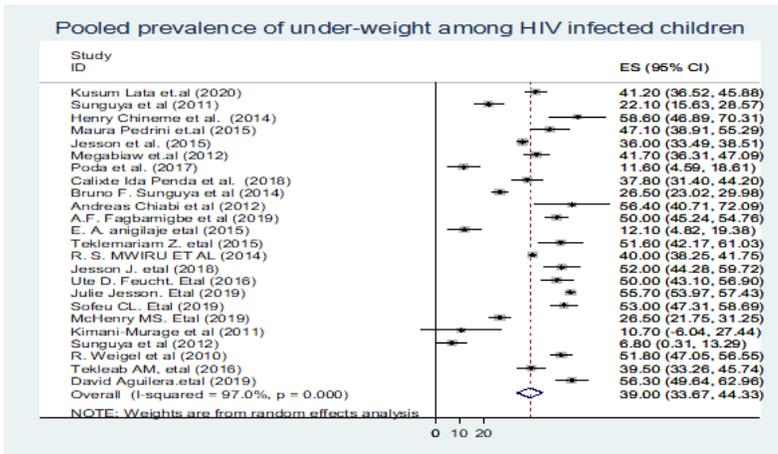


Figure 3

Forest plot for the pooled prevalence of under-weight among HIV infected children in sub-saran Africa, 2020.

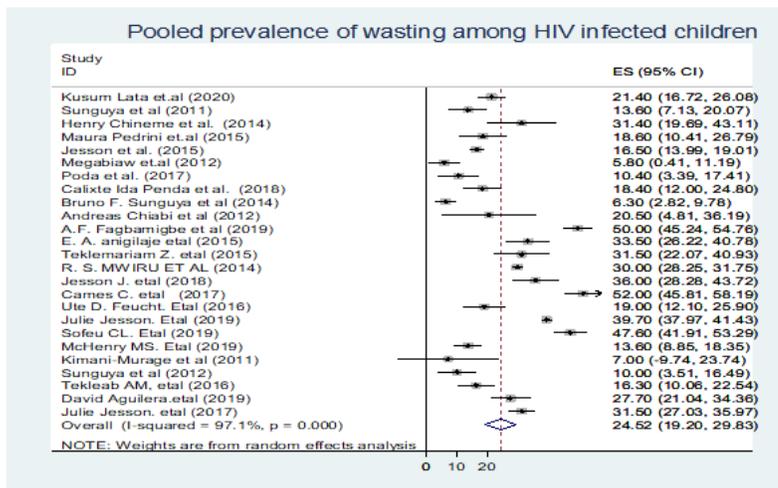


Figure 4

Forest plot for the pooled prevalence of wasting among HIV infected children in sub-saran Africa, 2020.

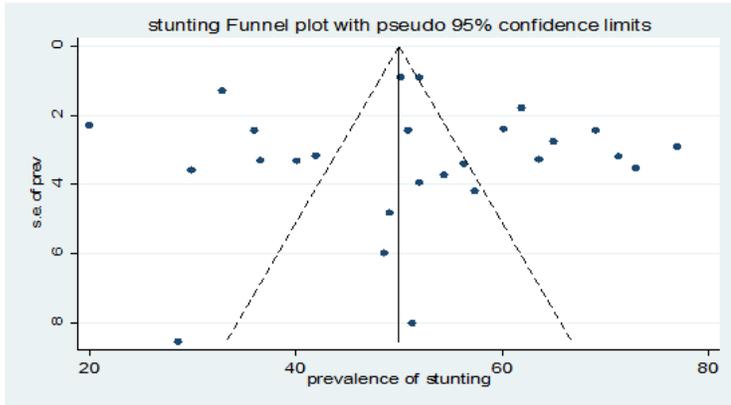


Figure 5

Funnel plot showing the symmetric distribution of articles for stunting among HIV infected children in sub-Saharan Africa, 2020.

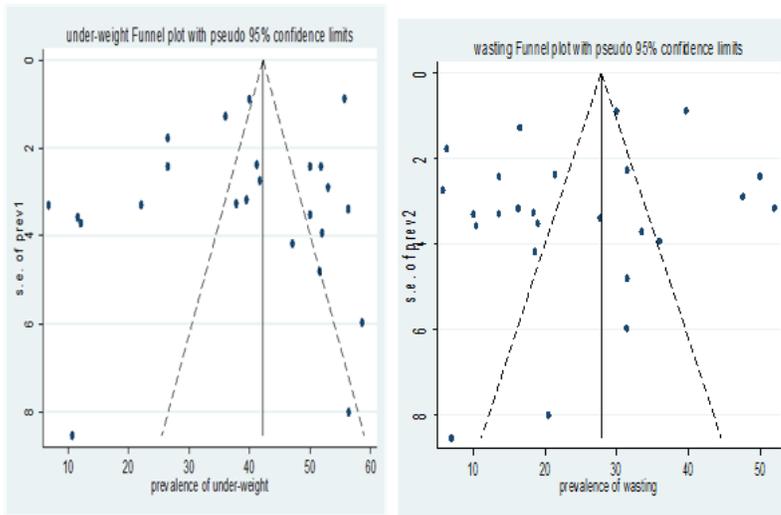


Figure 6

Funnel plot showing the symmetric distribution of articles for under-weight (left) and wasting (right) among HIV infected children in sub-Saharan Africa, 2020.

## food insecurity with stunting

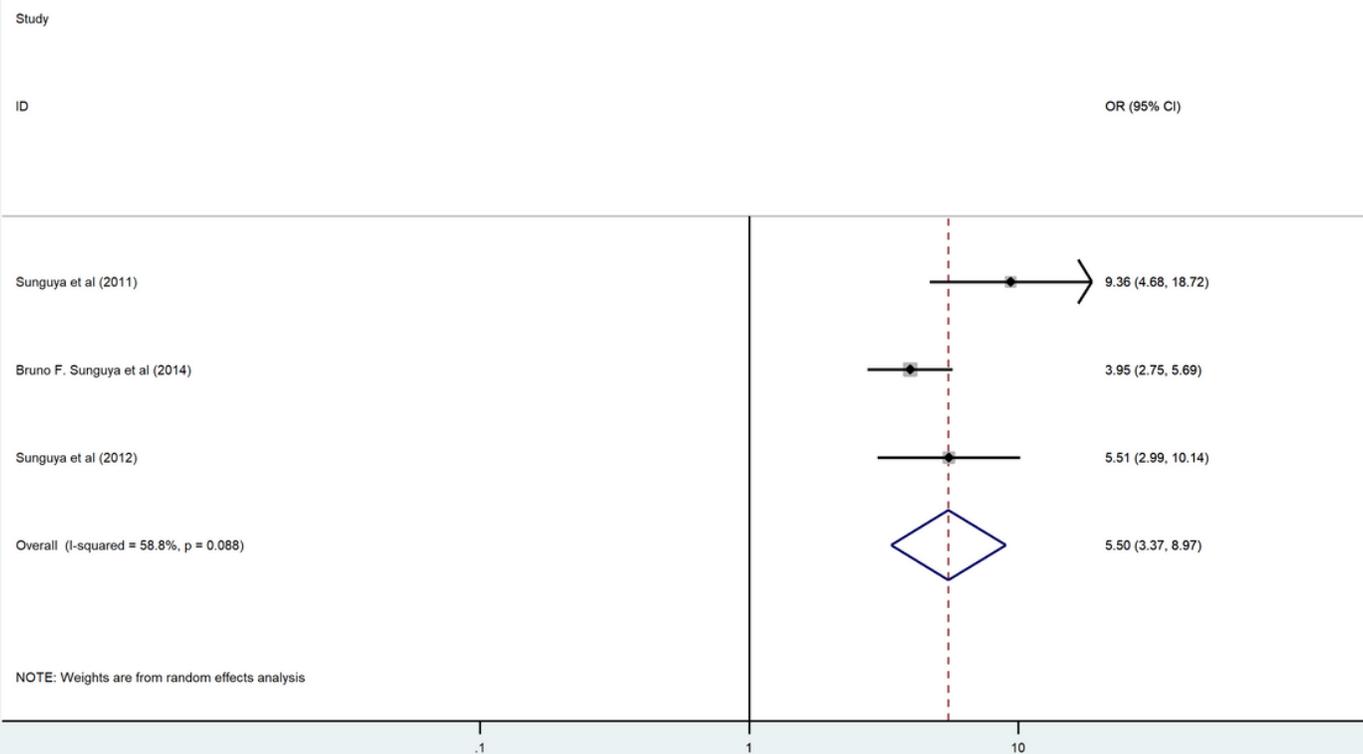
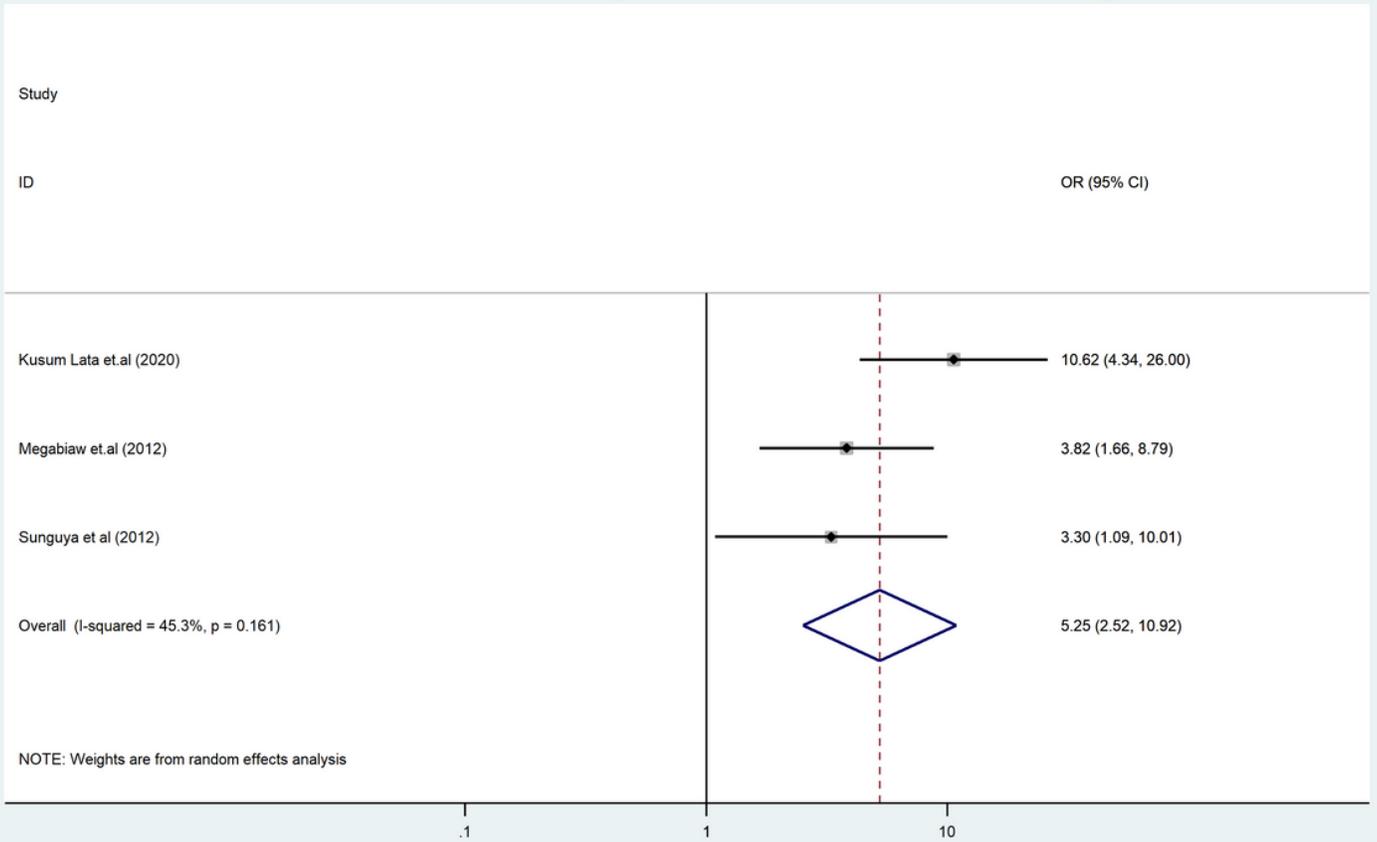


Figure 7

Association of household food insecurity and child under-weight among HIV infected children in sub-Saharan Africa, 2020.

## Association between family economic status and under-weight



**Figure 8**

Association of family economic status and child under-weight among HIV infected children in sub-Saharan Africa, 2020.

## Association between feeding frequency and under-weight

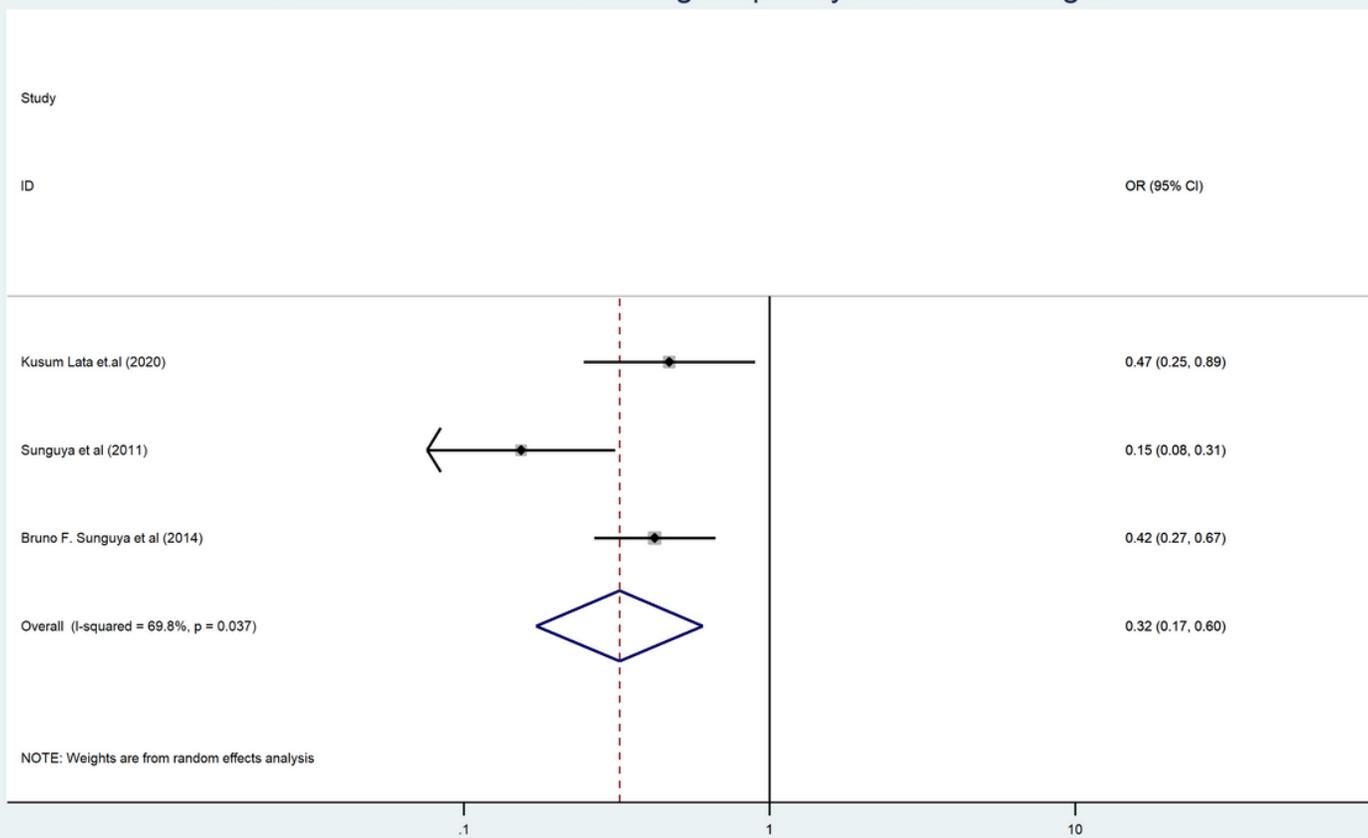
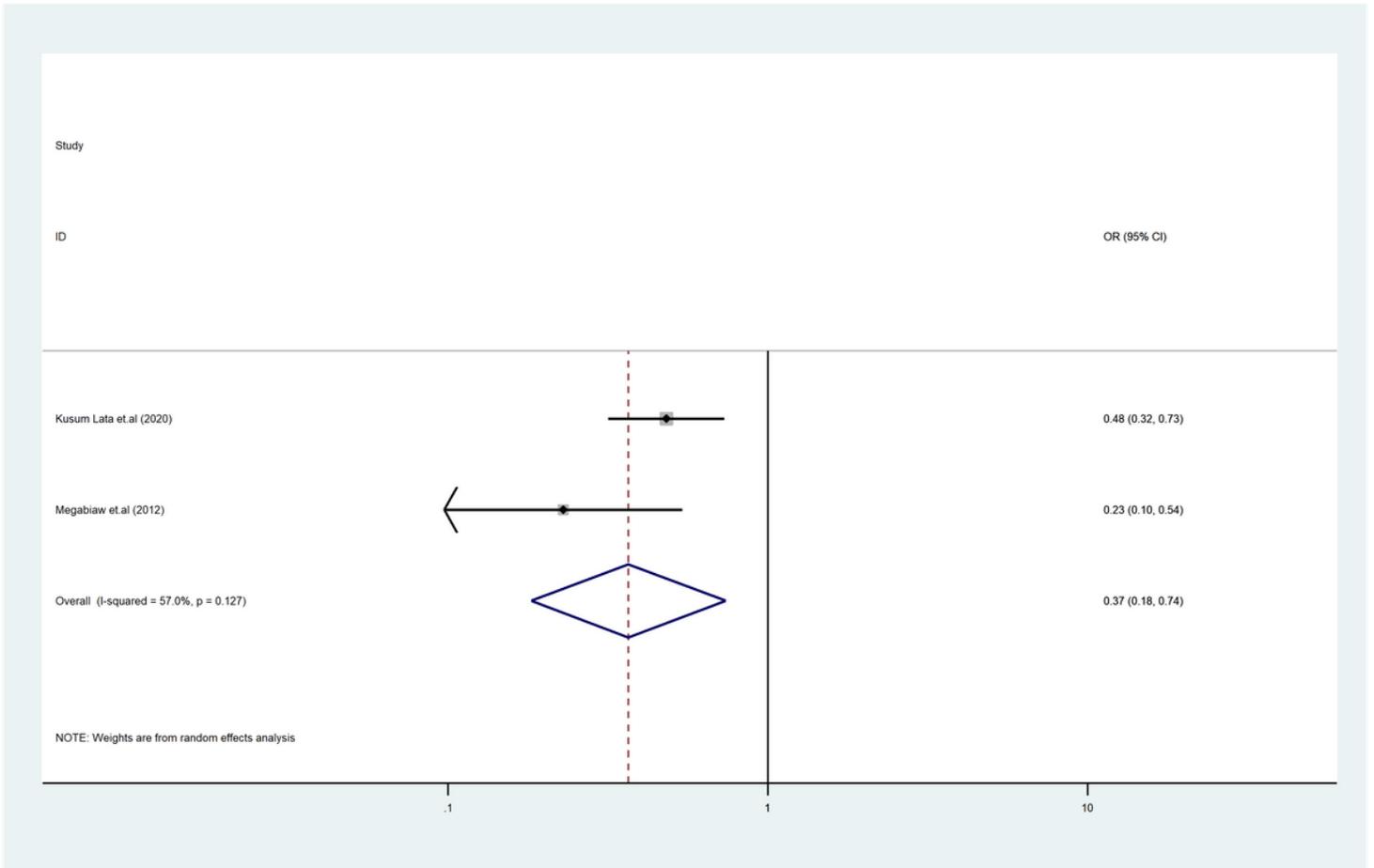


Figure 9

Association of feeding frequency and child under-weight among HIV infected children in sub-Saharan Africa, 2020.



**Figure 10**

Association of child caretaker taken dietary counseling and under-weight among HIV infected children in sub-Saharan Africa, 2020.