

# Chronic Energy Deficiency and Its Associated Factors Among Adults Living with HIV in Ethiopia: A Systematic Review and Meta-Analysis.

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## Systematic Review

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## Abstract

## Background

Chronic energy deficiency (CED), a form of adult undernutrition commonly defined using body mass index (BMI)  $< 18.5 \text{ kg/m}^2$ , remains a significant public health concern among people living with HIV in low-resource settings. Although several primary studies have investigated CED among adults living with HIV in Ethiopia, their findings vary across regions and settings.

## Objective

To estimate the pooled prevalence of chronic energy deficiency and synthesize the available evidence on factors associated with chronic energy deficiency among adults living with HIV in Ethiopia.

## Methods

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and was prospectively registered with PROSPERO (Registration No. CRD420261363646). A comprehensive literature search was conducted in PubMed/MEDLINE, Scopus, African Index Medicus (AIM), Web of Science, African Journals Online, and additional sources, including institutional repositories searched from Google Scholar and Google, from inception to 30 April 2026. Two reviewers independently screened studies, extracted data, and assessed methodological quality using the adapted Newcastle–Ottawa Scale. Using RStudio (version 4.5.3), random-effects meta-analysis was performed to estimate the pooled prevalence and pooled adjusted odds ratios (AORs). Subgroup analysis, leave-one-out sensitivity analysis, publication bias assessment, and exploratory meta-regression were conducted to investigate between-study heterogeneity.

## Results

Twelve studies involving 6,383 adults living with HIV were included in the review. Nine cross-sectional studies were included in the prevalence meta-analysis, yielding a pooled prevalence of 23% (95% CI: 18%–29%). Substantial between-study heterogeneity was observed ( $I^2 = 94.0\%$ ); therefore, the pooled estimate should be interpreted with caution. Chronic energy deficiency was associated with socioeconomic factors, including unemployment and low wealth index; dietary factors, including poor dietary diversity and household food insecurity; and clinical factors, including poor adherence to antiretroviral therapy, gastrointestinal symptoms, opportunistic infections, advanced WHO clinical stage, and lack of nutritional support, although the number of contributing studies and comparability of exposure definitions varied across associations. Leave-one-out sensitivity analysis demonstrated that no individual study substantially influenced the pooled prevalence estimate, while exploratory meta-regression explained only part of the observed heterogeneity.

## Conclusion

Chronic energy deficiency remains a significant nutritional challenge among adults living with HIV in Ethiopia. The available evidence suggests associations between CED and socioeconomic disadvantage, inadequate dietary intake, household food insecurity, and adverse clinical conditions, although the strength and consistency of evidence varied across factors. Strengthening and expanding integrated HIV care and nutrition interventions, particularly for vulnerable populations, may help improve nutritional outcomes. Given the substantial heterogeneity among studies and the observational nature of the evidence, these findings should be interpreted with appropriate caution.

## INTRODUCTION

Human immunodeficiency virus (HIV) remains a major global public health challenge despite substantial progress in prevention, diagnosis, and antiretroviral therapy (ART). According to recent estimates, millions of people continue to live with HIV worldwide, with the greatest burden occurring in sub-Saharan Africa, where nutritional deficiencies and food insecurity remain major public health concerns (1). Although expanded access to ART has significantly improved survival and quality of life, undernutrition continues to

adversely affect treatment outcomes, immune recovery, and long-term health among adults living with HIV. Consequently, improving nutritional status has become an essential component of comprehensive HIV care and treatment.

Chronic energy deficiency (CED), commonly defined as a body mass index (BMI) of less than 18.5 kg/m<sup>2</sup> among adults, is an important indicator of adult undernutrition and remains highly prevalent in many low- and middle-income countries (2). In this review, chronic energy deficiency (CED) is operationalized as a BMI < 18.5 kg/m<sup>2</sup> and is used as an indicator of adult underweight. This measure should be distinguished from broader malnutrition, as BMI primarily reflects body size and does not capture micronutrient deficiencies, body composition, or other dimensions of nutritional status. Among adults living with HIV, CED results from the complex interaction of inadequate dietary intake, increased metabolic demands, recurrent infections, gastrointestinal complications, socioeconomic deprivation, and reduced nutrient absorption (3, 4). Poor nutritional status is associated with impaired immune function, reduced physical capacity, delayed recovery from illness, and poorer response to ART. Because HIV infection and undernutrition interact reciprocally, nutritional assessment and management are integral components of HIV care (3, 5).

In Ethiopia, where HIV infection and food insecurity continue to coexist, CED remains a persistent public health problem despite the expansion of ART services and implementation of nutrition-sensitive interventions, including Nutritional Assessment, Counseling, and Support (NACS) (6, 7). Previous primary studies conducted in different regions of the country have reported varying estimates of CED prevalence and have identified several socioeconomic, dietary, and clinical factors associated with poor nutritional status among adults living with HIV (6, 8, 9). However, considerable heterogeneity exists across studies regarding study populations, geographic coverage, sample sizes, and methodological approaches, making it challenging to draw consistent conclusions from individual studies.

Several factors associated with chronic energy deficiency, including household food insecurity, low dietary diversity, unemployment, poor adherence to ART, opportunistic infections, gastrointestinal symptoms, and advanced WHO clinical stage, have been reported across individual studies (8, 10–13). Nevertheless, these associations have not been entirely consistent, and differences in exposure definitions, adjustment models, and study designs have contributed to variability in the reported findings. Furthermore, nearly half of the available studies were conducted in a single region of Ethiopia, underscoring the need for cautious interpretation of regional estimates and a comprehensive synthesis of the national evidence.

Although CED and adult undernutrition have been investigated in Ethiopia, previous studies have largely focused on individual regions or specific populations, and no recent systematic review has comprehensively synthesized both the pooled prevalence and factors associated with CED among adults living with HIV in Ethiopia using updated systematic review methodology. An up-to-date synthesis incorporating protocol registration, rigorous quality assessment, subgroup analysis, sensitivity analysis, publication bias assessment, and exploratory meta-regression is therefore warranted to provide a comprehensive understanding of the available evidence. Therefore, this systematic review and meta-analysis aimed to estimate the pooled prevalence of CED and synthesize the available evidence on factors associated with CED among adults living with HIV in Ethiopia. The findings are intended to support evidence-informed policy development, strengthen integrated HIV and nutrition services, identify research gaps, and guide future interventions aimed at improving nutritional outcomes among adults living with HIV. Thus, this study was aimed to estimate the pooled prevalence of chronic energy deficiency and synthesize the available evidence on factors associated with chronic energy deficiency among adults living with HIV in Ethiopia.

## **METHODS AND MATERIALS**

### **Study setting**

This systematic review synthesized evidence from observational studies conducted in health facilities providing HIV care and treatment services across different regions of Ethiopia. These facilities provide comprehensive chronic HIV care, including antiretroviral therapy, nutritional assessment and support, and management of opportunistic infections among adults living with HIV.

### **Study selection and protocol registration**

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines (14). The review protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) (Registration No. CRD420261363646), available at:

<https://www.crd.york.ac.uk/PROSPERO/view/CRD420261363646>. The protocol specified the study objectives, eligibility criteria, search strategy, data extraction procedures, quality assessment methods, and statistical analysis plan before commencing the review. The

review was conducted in accordance with the registered protocol, with minor methodological refinements documented and justified in Supplementary Table S1. Regarding the deviations from the original protocol, minor methodological refinements were made to improve the completeness and appropriateness of the review. Additional sources, including African Index Medicus, African Journals Online, Google Scholar, and Google, were searched to identify relevant grey literature. Prevalence synthesis was restricted to cross-sectional studies, while case-control studies were retained for associated-factor analyses when sufficiently comparable. Meta-regression and subgroup analyses were conducted as exploratory analyses because of the small number of contributing studies. These refinements were made to improve evidence retrieval and ensure appropriate interpretation of the available evidence. The deviations from the original protocol are summarized in Supplementary Table S1.

All retrieved records were imported into EndNote X9, and duplicate records were removed. Two reviewers independently screened titles and abstracts for eligibility, followed by independent full-text assessment of potentially eligible studies. Disagreements were resolved through discussion, and where consensus could not be reached, a third reviewer acted as an arbitrator. In addition, the reference lists of all included studies and relevant review articles were manually searched to identify additional eligible studies. Data extracted from each study included the first author's name, publication year, study region, study design, sample size, participant characteristics, prevalence of chronic energy deficiency, associated factors, operational definitions of exposures, and adjusted effect estimates with corresponding confidence intervals.

## Eligibility Criteria

### Inclusion Criteria

This review included observational studies (cross-sectional, case-control, and cohort studies) conducted among adults ( $\geq 18$  years) living with HIV in Ethiopia. Eligible studies reported the prevalence of chronic energy deficiency (CED), defined as a body mass index (BMI)  $< 18.5 \text{ kg/m}^2$ , and/or examined factors associated with CED using effect estimates such as adjusted odds ratios (AORs), odds ratios (ORs), or relative risks (RRs) with corresponding 95% confidence intervals. Both published and unpublished studies available in English were eligible for inclusion. However, restricting the review to English-language studies may have introduced language bias, which was acknowledged as a limitation.

### Exclusion Criteria

Reviews, editorials, commentaries, conference abstracts without full text, case reports, case series, qualitative studies, and studies involving non-human subjects were excluded. Studies conducted outside Ethiopia, studies involving children or pregnant women, and studies that did not provide sufficient information on the prevalence or associated factors of chronic energy deficiency were also excluded. Duplicate publications and studies identified as having a high risk of bias based on the methodological quality assessment were excluded from the final synthesis.

## Study Participants

The study participants comprised adults ( $\geq 18$  years) living with HIV who were receiving chronic HIV care and treatment services in Ethiopia.

## Measurement of outcome variables

The primary outcome of interest was chronic energy deficiency (CED) among adults living with HIV. Across the included studies, CED was consistently defined by the World Health Organization (WHO) criterion of BMI  $< 18.5 \text{ kg/m}^2$ , calculated as weight in kilograms divided by height in meters squared ( $\text{kg/m}^2$ ) (15). When reported, CED severity was classified as mild (BMI 17.0–18.49  $\text{kg/m}^2$ ), moderate (BMI 16.0–16.99  $\text{kg/m}^2$ ), and severe (BMI  $< 16.0 \text{ kg/m}^2$ ) (16, 17). For the meta-analysis, the outcome was extracted as a dichotomous variable (presence versus absence of CED), and prevalence was calculated as the proportion of adults living with HIV with BMI  $< 18.5 \text{ kg/m}^2$ .

For studies assessing associated factors, adjusted effect estimates were preferentially extracted because they accounted for potential confounding. However, because the included studies adjusted for different combinations of covariates, the pooled adjusted odds ratios should be interpreted cautiously.

Operational definitions and measurement methods for several exposure variables, including dietary diversity, household food insecurity, ART adherence, nutritional support, gastrointestinal symptoms, and opportunistic infections, were extracted from each included study and summarized in Supplementary Table S2 (which summarizes the operational definitions of pooled exposures). Although these variables measured similar constructs, assessment tools, classification criteria, and cut-off values varied across studies. These methodological differences were considered during data synthesis and interpretation, as they may have contributed to between-study heterogeneity and should be taken into account when interpreting the pooled estimates.

## Information source and Search strategy

A comprehensive literature search was conducted in PubMed/MEDLINE, Scopus, Web of Science Core Collection, African Index Medicus (AIM), and African Journals Online (AJOL) from database inception to 30 April 2026. Database-specific search strategies were developed using controlled vocabulary and free-text terms related to HIV, chronic energy deficiency/undernutrition, and Ethiopia, and were adapted to each database's indexing system and search syntax. No study-design filter was applied to maximize retrieval of potentially eligible observational studies. The complete search strategies for each information source, including the database/platform, exact search string, search date, filters, date limits, language restrictions, and number of records retrieved, are provided in Supplementary Table S3. Google Scholar and Google were also searched to identify potentially eligible publications and grey literature not indexed in the primary bibliographic databases. Given the limited and less standardized search functionality of these platforms, several combinations of terms related to HIV, chronic energy deficiency/undernutrition, nutritional status, and Ethiopia were used. Google Scholar searches were screened by reviewing the first 100 results for each search string, while Google was used to identify relevant institutional repositories, theses, dissertations, and other grey literature. The complete search strategies and supplementary information sources are presented in Supplementary Table S3.

The search strategy combined Medical Subject Headings (MeSH) and free-text terms with Boolean operators ("AND" and "OR"), truncation symbols, phrase searching, and database-specific syntax where appropriate. An example PubMed/MEDLINE search strategy is provided below to improve reproducibility.

("Chronic Energy Deficiency"[Title/Abstract] OR "chronic energy malnutrition"[Title/Abstract] OR undernutrition[Title/Abstract] OR malnutrition[Title/Abstract] OR underweight[Title/Abstract] OR "Body Mass Index"[Mesh] OR BMI[Title/Abstract]) AND ("HIV"[Mesh] OR HIV[Title/Abstract] OR "Human Immunodeficiency Virus"[Title/Abstract] OR AIDS[Title/Abstract] OR "People Living with HIV"[Title/Abstract] OR PLHIV[Title/Abstract]) AND (Ethiopia[Mesh] OR Ethiopia[Title/Abstract])

Reference lists of all eligible studies and relevant review articles were also manually screened to identify additional eligible publications. Duplicate records were removed in EndNote X9 before screening.

## Data extraction

To extract the data, a standardized Microsoft Excel tool was developed to ensure consistency and completeness of the collected data. The extraction form was pretested on a subset of included studies and refined accordingly. Key information to be extracted included study characteristics (first author, year of publication, study setting, and design), population characteristics (sample size, age, and sex), outcome data (prevalence of chronic energy deficiency defined as BMI < 18.5 kg/m<sup>2</sup>), exposure variables, effect estimates (odds ratios, adjusted odds ratios, or relative risks with 95% CIs), and measurement methods (BMI). For each quantitatively pooled association, the operational definition of the exposure, measurement instrument, cut-off or categorization, reference category, and covariates included in the multivariable model were extracted and summarized in Supplementary Table S4. Differences in these characteristics were considered when determining comparability and interpreting pooled estimates. Data extraction was performed independently by two reviewers. Any discrepancies were resolved through discussion and, where necessary, consultation with a third reviewer.

## Risk of bias assessment

Risk of bias assessment of the included studies was conducted using the adapted Newcastle–Ottawa Scale (NOS) for cross-sectional studies (18) and the original NOS for case-control studies (19). The assessment covered the predefined domains of participant selection (maximum of 5 stars), comparability (maximum of 2 stars), and outcome assessment (maximum of 3 stars), yielding a maximum score of 10 stars. Studies scoring 8–10 stars were classified as low risk of bias, those scoring 6–7 stars as moderate risk of bias, and those scoring ≤ 5 stars as high risk of bias. Studies classified as high risk of bias were excluded from the final quantitative

synthesis in accordance with the predefined eligibility criteria. Risk of bias assessment was conducted independently by two reviewers. Any discrepancies between reviewers were resolved through discussion and, when necessary, consultation with a third reviewer. The complete item-level assessment criteria and scoring procedure are provided in Supplementary Table S5 to facilitate reproducibility.

## Statistical analysis

Statistical analyses were conducted in R version 4.5.3 using the meta, metafor, and tidyverse packages (20, 21). Given the anticipated clinical and methodological heterogeneity across studies, pooled prevalence and associations were estimated using random-effects meta-analyses. For the prevalence synthesis, only cross-sectional studies were included to ensure population representativeness. Individual prevalence estimates were logit-transformed, and between-study variance ( $\tau^2$ ) was estimated using restricted maximum likelihood (REML). Ninety-five percent confidence intervals (CIs) were calculated using the Hartung–Knapp method, and pooled estimates were back-transformed to the prevalence scale for presentation.

For associated-factor analyses, adjusted odds ratios (AORs) were preferentially extracted to minimize confounding. AORs were log-transformed before pooling, and random-effects models were fitted using REML. Quantitative pooling was performed only when at least two studies assessed sufficiently comparable exposure–outcome relationships (matching exposure definitions, reference categories, outcome definitions, and effect measures). Cross-sectional and case-control studies were pooled under these strict criteria, but because both designs are observational and differ in covariate adjustment sets, sampling, and temporality, pooled estimates were interpreted strictly as summary measures of association rather than causal effects. Single-study factors were synthesized narratively.

Across the 12 included studies, 64 factors–outcome associations were reported. Heterogeneity across all analyses was assessed using Cochran’s (Q) and quantified using  $I^2$  and  $\tau^2$ . Potential sources of heterogeneity were explored via subgroup analyses, leave-one-out sensitivity analyses, and exploratory meta-regression. Publication bias and small-study effects were evaluated using visual inspection of funnel plots and Egger’s regression test. Because only nine studies contributed to the prevalence synthesis, these bias assessments were interpreted cautiously due to limited statistical power. Finally, all pooled prevalence estimates and summary AORs were reported with their corresponding 95% CIs.

## RESULTS

### Study selection

The literature search identified 563 records through electronic database searches and additional sources. Of these, 529 were obtained from databases such as PubMed/MEDLINE, Scopus, African Index Medicus (AIM), Web of Science, and African Journals Online, while 34 were sourced from website searches, including Google Scholar and Google. Of the 563 articles, 3 were duplicates. After removing the three duplicate records, 560 unique records remained for title and abstract screening. Of these, 547 records were excluded at the title and abstract screening stage, and 13 full-text reports were assessed for eligibility. One full-text report was excluded because the outcome did not meet the predefined CED criterion, resulting in 12 studies being included in the systematic review and meta-analysis (Fig. 1). The most common reasons for excluding full-text articles were an ineligible study population, failure to report chronic energy deficiency as defined by BMI < 18.5 kg/m<sup>2</sup>, insufficient data to estimate prevalence or associated factors, duplicate publication, or failure to meet the methodological quality criteria.

### Eligibility

### Screening

Reports excluded with reasons (n = 1)

Duplicate records removed (n = 3)

Reports not retrieved (n = 547)

### Included

### Identification

### Characteristics of included studies

A total of 12 observational studies involving 6,383 adults living with HIV were included in this review. Nine studies used a cross-sectional design, and three were case-control studies. The studies were conducted between 2013 and 2026 across several regions of Ethiopia, with the largest proportion from Oromia, followed by South Ethiopia, Amhara, Southwest Ethiopia, and Tigray. Sample sizes ranged from 102 to 1,062 participants (Table 1). All studies assessed chronic energy deficiency using the World Health Organization definition of BMI < 18.5 kg/m<sup>2</sup>. However, operational definitions of several exposure variables varied across studies. In addition, the multivariable models used to estimate adjusted associations differed among studies, which should be considered when interpreting pooled effect estimates.

Table 1  
Characteristics of included studies assessing chronic energy deficiency among adults living with HIV in Ethiopia, 2026.

| S.no | Author                        | Year of publication | Region             | Study setting      | Percentage female | Study design    | Sample size | Response rate (%) | Proportion of CED (%) |
|------|-------------------------------|---------------------|--------------------|--------------------|-------------------|-----------------|-------------|-------------------|-----------------------|
| 1    | Mitiku et al. (10)            | 2016                | Amhara             | Health institution | 71.5              | Cross-sectional | 452         | 100               | 23.20                 |
| 2    | Gebremichael et al. (8)       | 2018                | Oromia             | Health institution | 52.3              | Cross-sectional | 505         | 98.6              | 23.60                 |
| 3    | Daka DW and Ergiba MS(11)     | 2020                | Oromia             | Health institution | 61                | Cross-sectional | 1062        | 100               | 34                    |
| 4    | Regassa TM and Gudeta TA (12) | 2022                | Southwest Ethiopia | Health institution | 61.2              | Cross-sectional | 961         | 95.4              | 16                    |
| 5    | Hailemariam et al. (13)       | 2013                | South Ethiopia     | Health institution | 59                | Cross-sectional | 520         | 100               | 12.3                  |
| 6    | Tassew et al. (22)            | 2026                | Amhara             | Health institution | 59                | Cross-sectional | 410         | 97                | 24                    |
| 7    | Tekelehaimanot et al (23)     | 2020                | Oromia             | Health institution | 70.5              | Case-control    | 678         | 100               | 50                    |
| 8    | Assefa et al. (24)            | 2023                | Oromia             | Health institution | 65.6              | Case-control    | 279         | 91.2              | 30.4                  |
| 9    | Belete NK, et al. (25)        | 2025                | South Ethiopia     | Health institution | 51.5              | Cross-sectional | 406         | 98.1              | 28                    |
| 10   | Weldehaweria et al (26)       | 2017                | Tigray             | Health institution | 57.3              | Case-control    | 340         | 99.4              | 49.7                  |
| 11   | Oumer et al. (27)             | 2019                | South Ethiopia     | Health institution | 56.46             | Cross-sectional | 333         | 100               | 23.72                 |
| 12   | Dedha et al. (28)             | 2017                | Oromia             | Health institution | 58.6              | Cross-sectional | 437         | 95                | 30                    |

CED: Chronic Energy Deficiency;

## Risk of bias assessment

All 12 included studies were classified as having a low risk of bias, with Newcastle–Ottawa Scale scores ranging from 8 to 9 stars; no study was classified as having moderate or high risk of bias (Table 2). The risk-of-bias assessment was considered when interpreting the pooled estimates.

Table 2  
Risk of bias assessment of included studies using the adapted Newcastle–Ottawa Scale for cross-sectional studies and the Newcastle–Ottawa Scale for case-control studies, Ethiopia, 2026.

| Authors or               | Year | Selection | Comparability | Outcome | Total |
|--------------------------|------|-----------|---------------|---------|-------|
| Mitiku et al.            | 2016 | 4         | 2             | 2       | 8     |
| Gebremichael et al.      | 2018 | 3         | 2             | 3       | 8     |
| Daka DW and Ergiba       | 2020 | 3         | 2             | 3       | 8     |
| Regassa TM and Gudeta TA | 2022 | 4         | 2             | 2       | 8     |
| Hailemariam et al.       | 2013 | 4         | 2             | 3       | 9     |
| Tassew et al.            | 2026 | 3         | 2             | 3       | 8     |
| Tekelehaimanot et al.    | 2020 | 3         | 2             | 3       | 8     |
| Assefa et al.            | 2023 | 4         | 2             | 3       | 9     |
| Belete NK, et al.        | 2025 | 4         | 2             | 3       | 9     |
| Weldehaweria et al.      | 2017 | 4         | 2             | 2       | 8     |
| Oumer et al.             | 2019 | 4         | 2             | 2       | 8     |
| Dedha et al.             | 2017 | 3         | 2             | 3       | 8     |

## Publication bias

Visual inspection of the funnel plot suggested some asymmetry; however, Egger's regression test did not provide statistically significant evidence of funnel-plot asymmetry ( $p = 0.1204$ ) (Fig. 2). Given that only nine studies contributed to the prevalence synthesis, this finding should be interpreted cautiously because of the limited statistical power to detect small-study effects or publication bias.

## Pooled proportion of chronic energy deficiency

Nine cross-sectional studies of 5,086 adults living with HIV were included in the prevalence meta-analysis. The pooled prevalence of chronic energy deficiency was 23.0% (95% CI: 18.0–29.0%). Considerable between-study heterogeneity was observed ( $I^2 = 94.0\%$ ;  $\tau^2 = 0.1448$ ;  $p < 0.0001$ ) (Fig. 3). Therefore, the pooled prevalence should be interpreted as an overall summary estimate across heterogeneous study settings rather than as a uniform national prevalence estimate.

## Subgroup analysis

To explore potential sources of heterogeneity in the pooled prevalence estimates, subgroup analyses were conducted by study region and publication year. The exploratory regional subgroup analysis showed variation in prevalence estimates across the regions represented in the included studies. The pooled prevalence was 29% in Oromia, 23% in Amhara, and 21% in South Ethiopia, while a single study from Southwest Ethiopia reported a prevalence of 16%. Substantial heterogeneity was observed in the Oromia ( $I^2 = 87.7\%$ ;  $p = 0.0003$ ) and South Ethiopia ( $I^2 = 94.5\%$ ;  $p < 0.0001$ ) subgroups, whereas no heterogeneity was observed in Amhara ( $I^2 = 0\%$ ;  $p = 0.7571$ ) (Fig. 4). Because several regional estimates were based on one or a small number of studies, these findings should be interpreted as descriptive variations rather than robust evidence of regional differences.

Furthermore, an exploratory subgroup analysis by publication year was conducted; however, most year-specific categories contained only one study, limiting interpretability.

## Sensitivity analysis

A sensitivity analysis was conducted to assess the effect of each study on the overall pooled prevalence estimate. Leave-one-out analyses showed that excluding any individual study did not materially change the pooled prevalence estimate, indicating that no individual study disproportionately influenced the pooled prevalence estimate; however, substantial between-study heterogeneity remained (Fig. 5).

# Exploratory meta-regression analysis

Single-moderator exploratory meta-regression analyses were conducted to assess whether publication year, sample size, geographic region, and the proportion of female participants could explain between-study heterogeneity. Because only nine studies contributed to the prevalence meta-analysis, these analyses were considered exploratory and should be interpreted cautiously. None of the evaluated moderators was statistically significantly associated with prevalence. Geographic region accounted for approximately 14% of the estimated between-study variability; however, the overall moderator test was not statistically significant, and substantial residual heterogeneity remained (Table 3). These findings should not be interpreted as evidence that the evaluated study-level characteristics explain the observed heterogeneity. Given the limited number of studies, no attempt was made to develop a multivariable explanatory meta-regression model.

Table 3

Exploratory meta-regression analyses of potential sources of heterogeneity in the prevalence of chronic energy deficiency among adults living with HIV in Ethiopia, 2026.

| Moderator                       | Coefficient ( $\beta$ ) | SE     | 95%CI         | QM (df)    | p-value | R <sup>2</sup> (%) |
|---------------------------------|-------------------------|--------|---------------|------------|---------|--------------------|
| Publication year                | 0.0298                  | 0.0353 | -0.054, 0.113 | 0.7102 (1) | 0.427   | 0.00               |
| Sample size                     | 0.0000                  | 0.0006 | -0.001, 0.001 | 0.003 (1)  | 0.958   | 0.00               |
| Female percentage               | -0.0096                 | 0.0232 | -0.064, 0.045 | 0.47 (1)   | 0.6913  | 0.00               |
| Region (overall moderator test) | —                       | —      | —             | 1.35 (5)   | 0.357   | 14.16              |
| Oromia                          | 0.2850                  | 0.3388 | -0.586, 1.156 | —          | 0.439   | —                  |
| South Ethiopia                  | -0.1682                 | 0.3422 | -1.048, 0.712 | —          | 0.644   | —                  |
| Southwest Ethiopia              | -0.4734                 | 0.4516 | -1.634, 0.688 | —          | 0.3426  | —                  |

$\beta$  = regression coefficient; SE = standard error; CI = confidence interval; QM = test of moderators; R<sup>2</sup> = proportion of between-study heterogeneity explained by the moderator

## Factors associated with chronic energy deficiency

In this review, factors associated with chronic energy deficiency reported in at least two studies were pooled quantitatively, whereas those reported in a single study were presented narratively. In this systematic review and meta-analysis, marital status (widowed), employment status (unemployed), low wealth index, poor adherence to ART, low dietary diversity, household food insecurity, presence of gastrointestinal symptoms, presence of opportunistic infection, lack of nutritional support, and WHO clinical stage III/IV were significantly associated with chronic energy deficiency.

Several sociodemographic and economic, dietary, and clinical factors were significantly associated with chronic energy deficiency (CED) among adults living with HIV in Ethiopia. Based on two studies (10, 11), widowed marital status was associated with higher odds of CED compared with being married (AOR = 1.85; 95% CI: 1.23–2.77), with no evidence of between-study heterogeneity ( $I^2$  = 0.0%;  $p$  = 0.5713). Similarly, unemployment was associated with higher odds of CED (AOR = 3.54; 95% CI: 2.59–4.84;  $I^2$  = 0.0%;  $p$  = 0.8593) based on two studies (13, 29). Two studies (24, 26) also indicated that participants with a low wealth index had higher odds of CED than those with a high wealth index (AOR = 5.94; 95% CI: 2.96–11.94;  $I^2$  = 0.0%;  $p$  = 0.5973). Because these pooled estimates were derived from only two studies, they should be interpreted with caution.

Clinical and nutritional factors were also associated with CED. Poor adherence to antiretroviral therapy (ART), reported in three studies (22, 25, 26), was associated with higher odds of CED (AOR = 5.32; 95% CI: 3.36–8.42), with moderate between-study heterogeneity ( $I^2$  = 52.8%;  $p$  = 0.1204). Low dietary diversity, examined in four studies (22–25), was associated with increased odds of CED (AOR = 3.03; 95% CI: 1.96–4.70), with low heterogeneity ( $I^2$  = 37.7%;  $p$  = 0.1857). Household food insecurity, assessed in two studies (22, 28), was likewise associated with higher odds of CED (AOR = 1.80; 95% CI: 1.21–2.69), with minimal heterogeneity ( $I^2$  = 2.0%;  $p$  = 0.3124). As this estimate was based on only two studies, it should also be interpreted cautiously.

Among clinical characteristics, gastrointestinal (GI) symptoms were associated with higher odds of CED in three studies (12, 13, 28) (AOR = 2.70; 95% CI: 1.42–5.14), although substantial heterogeneity was observed ( $I^2$  = 72.9%;  $p$  = 0.0250). The presence of one or more opportunistic infections, reported in four studies (13, 22, 27, 29), was associated with higher odds of CED (AOR = 2.47; 95% CI: 1.83–

3.35), with no evidence of between-study heterogeneity ( $I^2 = 0.0\%$ ;  $p = 0.6571$ ). Absence of nutritional support or counselling, evaluated in two studies (24, 28), was associated with increased odds of CED (AOR = 2.41; 95% CI: 1.58–3.66;  $I^2 = 0.0\%$ ;  $p = 0.4372$ ) when compared to the presence of nutritional support, although this finding should be interpreted cautiously because it was based on only two studies.

Finally, advanced HIV disease (WHO clinical stage III/IV), reported in four studies (12, 23, 27, 29), was associated with higher odds of CED compared with WHO clinical stage I (AOR = 4.04; 95% CI: 2.97–5.49), with no evidence of between-study heterogeneity ( $I^2 = 0.0\%$ ;  $p = 0.5373$ ) (Table 4).

Table 4

Random-effects meta-analysis of factors associated with chronic energy deficiency among adults living with HIV in Ethiopia, 2026.

| Variables                              | Number of studies pooled | Authors (Year of publication)    | Study sample size | Effect estimates<br>AOR(95%CI) | Pooled AOR (95% CI); I <sup>2</sup> ; p-value                |
|----------------------------------------|--------------------------|----------------------------------|-------------------|--------------------------------|--------------------------------------------------------------|
| Marital status<br>(widowed)            | 2                        | Mitiku et al. (2016)             | 452               | 2.18 (1.08–4.40)               | <b>1.85 (1.23–2.77),</b><br>I <sup>2</sup> =0.0%; p = 0.573  |
|                                        |                          | Daka DW and Ergiba (2020)        | 1062              | 1.70 (1.03–2.80)               |                                                              |
| Employment status<br>(unemployed)      | 2                        | Gebremichael et al. (2018)       | 505               | 3.40 (1.98–5.83)               | <b>3.54 (2.59–4.84)</b><br>I <sup>2</sup> =0.0%; p = 0.859   |
|                                        |                          | Hailemariam et al. (2013)        | 520               | 3.61 (2.46–5.30)               |                                                              |
| Wealth index (low)                     | 2                        | Assefa et al. (2023)             | 279               | 6.63 (2.96–14.85)              | <b>5.94 (2.96–11.94)</b><br>I <sup>2</sup> =0.0%; p = 0.597  |
|                                        |                          | Weldehaweria et al. (2017)       | 340               | 4.30 (1.07–17.25)              |                                                              |
| Adherence to ART<br>(poor)             | 3                        | Weldehaweria et al. (2017)       | 340               | 6.80 (2.34–17.29)              | <b>5.32 (3.36, 8.42)</b><br>I <sup>2</sup> =52.8%; p = 0.120 |
|                                        |                          | Tassew et al. (2026)             | 410               | 4.10 (1.64–10.26)              |                                                              |
|                                        |                          | Belete NK et al. (2025)          | 406               | 3.60 (1.78–7.28)               |                                                              |
| Dietary diversity                      | 4                        | Assefa et al. (2023)             | 279               | 2.36 (1.33–4.20)               | <b>3.03 (1.96–4.70)</b><br>I <sup>2</sup> =37.7%; p = 0.186  |
|                                        |                          | Tassew et al. (2026)             | 410               | 2.19 (1.19–4.04)               |                                                              |
|                                        |                          | Belete NK et al. (2025)          | 406               | 4.80 (2.84–8.10)               |                                                              |
|                                        |                          | Tekelehaimanot et al. (2020)     | 678               | 3.50 (1.01–12.08)              |                                                              |
| Food security status<br>(low)          | 2                        | Tassew et al. (2026)             | 410               | 2.53 (1.17–5.47)               | <b>1.80 (1.21–2.69)</b><br>I <sup>2</sup> =2.0%; p = 0.312   |
|                                        |                          | Dedha et al. (2017)              | 437               | 1.59 (1.01–2.52)               |                                                              |
| GI symptoms<br>(presence)              | 3                        | Regassa TM and Gudeta TA. (2022) | 961               | 2.60 (1.52–4.45)               | <b>2.70 (1.42–5.14)</b><br>I <sup>2</sup> =72.9%; p = 0.025  |
|                                        |                          | Hailemariam et al. (2013)        | 520               | 5.30 (2.58–10.88)              |                                                              |
|                                        |                          | Dedha et al. (2017)              | 437               | 1.64 (1.04–2.60)               |                                                              |
| Opportunistic infections<br>(presence) | 4                        | Gebremichael et al. (2018)       | 505               | 2.30 (1.18–4.47)               | <b>2.47 (1.83–3.35)</b><br>I <sup>2</sup> =0.0%; p = 0.657   |
|                                        |                          | Hailemariam et al. (2013)        | 520               | 3.10 (1.90–5.05)               |                                                              |
|                                        |                          | Tassew et al. (2026)             | 410               | 2.35 (1.11–4.97)               |                                                              |
|                                        |                          | Oumer et al. (2019)              | 333               | 1.89 (1.02–3.35)               |                                                              |

AOR = Adjusted Odds Ratio; ART = Antiretroviral Therapy; CI = Confidence Interval; WHO = World Health Organization

| Variables                                                                                                          | Number of studies pooled | Authors (Year of publication)    | Study sample size | Effect estimates<br>AOR(95%CI) | Pooled AOR (95% CI); I <sup>2</sup> ; p-value              |
|--------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------|-------------------|--------------------------------|------------------------------------------------------------|
| Nutritional support (absence)                                                                                      | 2                        | Assefa et al. (2023)             | 279               | 3.22 (1.38–7.51)               | <b>2.41 (1.58–3.66)</b><br>I <sup>2</sup> =0.0%; p = 0.437 |
|                                                                                                                    |                          | Dedha et al. (2017)              | 437               | 2.19 (1.35–3.55)               |                                                            |
| WHO clinical stage (III/IV)                                                                                        | 4                        | Gebremichael et al. (2018)       | 505               | 3.30 (1.74–6.27)               | <b>4.04 (2.97–5.49)</b><br>I <sup>2</sup> =0.0%; p = 0.537 |
|                                                                                                                    |                          | Regassa TM and Gudeta TA. (2022) | 961               | 2.80 (1.30–6.02)               |                                                            |
|                                                                                                                    |                          | Tekelehaimanot et al. (2020)     | 678               | 4.30 (2.20–8.39)               |                                                            |
|                                                                                                                    |                          | Oumer et al. (2019)              | 333               | 5.10 (3.13–8.31)               |                                                            |
| AOR = Adjusted Odds Ratio; ART = Antiretroviral Therapy; CI = Confidence Interval; WHO = World Health Organization |                          |                                  |                   |                                |                                                            |

Finally, in this review single studies reported associations between age (18–29) (10), presence of anemia (10), access to water supply (11), functional status (bedridden or ambulatory) (11), presence of depression (26), place of residence (rural) (23), low meal frequency (23), and age ( $\geq 45$ ) (12) with CED among adult HIV patients. Although several included studies assessed age and sex as potential associated factors of chronic energy deficiency, findings were inconsistent across studies and therefore could not be quantitatively pooled.

## DISCUSSION

This systematic review and meta-analysis found that the pooled prevalence of chronic energy deficiency (CED) among adults living with HIV in Ethiopia was 23.0% (95% CI: 18.0–29.0%), indicating that undernutrition remains a substantial public health concern in this population. However, the high level of heterogeneity among the included studies ( $I^2 = 94.0\%$ ) suggests considerable variation in prevalence estimates across studies. Subgroup analysis indicated differences in CED prevalence by publication year; however, this finding should be interpreted with caution, as only the 2019 subgroup included more than one study, while all other subgroups were represented by a single study. Therefore, the observed variations are unlikely to reflect temporal trends alone and may be attributable to differences in study populations, geographic settings, or methodological characteristics. This interpretation is further supported by the exploratory meta-regression analysis, which did not identify publication year as a statistically significant contributor to between-study heterogeneity. Although a random-effects model, subgroup analyses, and additional exploratory analyses were applied to address heterogeneity, the pooled estimate should be interpreted cautiously, as variations in study populations, settings, and methodological approaches may have contributed to the observed differences in prevalence estimates. Globally, the prevalence of CED among people living with HIV has declined considerably over the past two decades, following widespread access to antiretroviral therapy (ART), earlier HIV diagnosis, and improved nutritional care, particularly in high-income countries, where undernutrition has become relatively uncommon and the burden has shifted toward overweight and metabolic disorders (30, 31). In contrast, studies from low- and middle-income countries, particularly those in sub-Saharan Africa, continue to report CED prevalence ranging from approximately 20% to 40%, reflecting persistent food insecurity, poverty, and limitations in integrating nutrition into HIV care (32, 33). Thus, the pooled estimate identified in this review is broadly comparable with findings reported from other resource-limited settings in sub-Saharan Africa.

Regional subgroup analysis showed variations in the prevalence of chronic energy deficiency among adults living with HIV across Ethiopian regions. The highest pooled prevalence was observed in Oromia Region (29%), followed by Amhara (23%) and South Ethiopia (21%). However, these regional differences should be interpreted cautiously because some estimates were based on a limited number of studies, including single-study estimates. Exploratory meta-regression further indicated that geographic region was not a statistically significant moderator of CED prevalence and accounted for only 14.16% of the between-study heterogeneity, with substantial residual heterogeneity remaining unexplained. Thus, the observed regional differences should be considered potential variations rather than evidence of regional effects. Similar regional variations have been reported in studies conducted across sub-Saharan Africa, where differences in local context and health system capacity have been associated with variability in nutritional outcomes among adults living with HIV (32, 33). Consequently, the observed variation may reflect differences in study characteristics, participant populations,

healthcare settings, or methodological approaches rather than true regional differences. These findings highlight the need for additional well-designed studies from underrepresented regions to improve the precision and representativeness of regional estimates.

The present systematic review and meta-analysis identified several factors associated with chronic energy deficiency (CED) among adults living with HIV. The findings are organized into four broader thematic domains: socioeconomic vulnerability; food access and dietary quality; HIV treatment and disease severity; and clinical and health-service factors. Because most contributing studies were observational, particularly cross-sectional, these findings should be interpreted as associations rather than causal relationships.

In this study, socioeconomic characteristics were consistently associated with CED. Widowed marital status was significantly associated with higher odds of CED compared with being married. Similar findings have been reported among adults living with HIV in Ethiopia and other sub-Saharan African settings, possibly reflecting differences in social and economic support. However, the pooled estimate was based on only two studies and should therefore be interpreted cautiously (8, 23, 34, 35). Some studies, particularly from urban settings, reported no significant association, suggesting that the relationship may vary by social support systems and socioeconomic context (36). Similarly, unemployment was associated with higher odds of CED. This finding is consistent with studies among adults living with HIV in Ethiopia and Tanzania, where socioeconomic disadvantage and lower economic resources were linked to poorer nutritional status (13, 29, 37). However, because the included studies were observational, the direction of this association cannot be established. Participants with a low wealth index had higher odds of CED than those with a high wealth index. Similar associations between socioeconomic disadvantage and undernutrition have been reported among adults living with HIV in Ethiopia and Malawi (13, 23, 38). Wealth may influence access to adequate food, healthcare, and other essential resources; however, differences in the measurement of socioeconomic status across studies should be considered. Nevertheless, the pooled estimates for marital status, employment, and wealth were each based on only two studies, and differences in socioeconomic measurement across studies warrant cautious interpretation.

In the present study, dietary and household food-security conditions were also associated with CED. Low dietary diversity was associated with higher odds of CED, consistent with evidence from Ethiopia and other low-income settings linking inadequate dietary diversity with poorer nutritional status among adults living with HIV (39, 40). However, differences in dietary diversity assessment tools and cut-off values across studies may have contributed to variability in the pooled estimate. Household food insecurity was similarly associated with higher odds of CED, consistent with evidence from sub-Saharan Africa showing that food insecurity remains an important nutritional challenge among people living with HIV (41). Nevertheless, this pooled estimate was based on only two studies, and differences in food-insecurity measurement should be considered when interpreting the finding. Moreover, a lack of nutritional support or counselling was associated with higher odds of CED. Comparable findings have been reported in studies evaluating nutritional care among adults living with HIV (33). This association further highlights the potential importance of nutritional care within HIV services; however, the estimate was also based on only two studies, and definitions of nutritional support varied across studies.

The findings of this study showed that treatment-related and disease-severity factors were associated with CED. Poor adherence to antiretroviral therapy (ART) was associated with higher odds of CED, consistent with studies from Ethiopia, Uganda, and South Africa (8, 11). However, the cross-sectional nature of most contributing studies means that reverse causation cannot be excluded, as poor nutritional status may also adversely affect treatment adherence. Differences in how ART adherence was assessed may also explain some of the observed heterogeneity. WHO clinical stage (III/IV) was also associated with higher odds of CED compared with clinical stage I, consistent with findings from Ethiopia and other sub-Saharan African countries (33, 42). Nevertheless, reverse causation cannot be ruled out because advanced disease and poor nutritional status may coexist, and most included studies used cross-sectional designs.

Clinical conditions, particularly gastrointestinal symptoms and opportunistic infections, were associated with CED. Participants reporting gastrointestinal symptoms had higher odds of CED, consistent with evidence from Ethiopia and other African settings (13, 32). Gastrointestinal symptoms may interfere with food intake and nutrient absorption; however, reverse causation cannot be excluded because poor nutritional status may also contribute to gastrointestinal problems. The substantial heterogeneity observed for this association may partly reflect differences in symptom definitions and study populations. Similarly, adults with one or more opportunistic infections had higher odds of CED than those without such infections, consistent with evidence from sub-Saharan Africa (42, 43). Because the evidence was derived mainly from observational studies, these findings should be interpreted as associations rather than causal relationships.

Evidence for associations between age, sex, and CED was inconsistent across studies, making quantitative pooling impossible. Similar inconsistencies have been reported in Ethiopia and other settings, suggesting that demographic differences may vary by population

characteristics, socioeconomic conditions, and methodological approaches (10, 12, 23). Further prospective studies using standardized definitions and nutritional assessment methods are needed to clarify these relationships.

Taken together, the findings suggest that CED among adults living with HIV is associated with interrelated socioeconomic, dietary, treatment-related, and clinical factors rather than a single underlying characteristic. However, the strength of evidence varies substantially across associations because several pooled estimates were based on only two studies, exposure definitions differed across studies, and most studies used cross-sectional designs. Given the observational nature of the evidence, substantial heterogeneity, and limited number of studies contributing to several associations, the pooled estimates should be interpreted as suggestive evidence of association rather than definitive evidence of causal relationships.

The factors identified in this review overlap with those reported in other sub-Saharan African settings; however, differences in study populations, exposure definitions, healthcare systems, and socioeconomic contexts limit direct comparability and generalizability. Food insecurity, poverty, poor ART adherence, opportunistic infections, and inadequate nutritional support remain common drivers of undernutrition among people living with HIV across the region.

The findings of this review have important implications for HIV care and nutrition policy in Ethiopia. The findings may support continued consideration of integrated nutritional assessment, counselling and support within HIV care, alongside interventions addressing food insecurity, dietary quality and treatment adherence. However, the observational evidence and substantial heterogeneity do not permit conclusions about the effectiveness of specific interventions.

## **Strengths and limitations of the study**

### **Strengths of the study**

This systematic review and meta-analysis provide a comprehensive synthesis of the available evidence on the prevalence and factors associated with chronic energy deficiency (CED) among adults living with HIV in Ethiopia. By combining data from multiple studies, the review increased statistical power and produced more precise estimates than individual studies alone. A random-effects meta-analysis was used to synthesize prevalence estimates and comparable estimates of associated factors across studies, while subgroup analyses, sensitivity analyses, and exploratory meta-regression helped assess the robustness of the findings and explore potential sources of heterogeneity. Furthermore, although several pooled factor analyses showed low statistical heterogeneity, interpretation remains limited by the small number of contributing studies, differences in exposure definitions and covariate adjustment, and the predominance of cross-sectional designs. The inclusion of studies from multiple regions of Ethiopia also provides valuable insights into the epidemiology of CED among adults living with HIV, although findings should be interpreted in light of the underrepresentation of some regions.

### **Limitations of the study**

This review has several limitations that should be considered when interpreting the findings. First, substantial between-study heterogeneity persisted despite subgroup analyses and exploratory meta-regression, which may reflect differences in study populations, settings, measurement approaches, and other methodological characteristics. Second, most included studies used cross-sectional designs, limiting causal inference and raising the possibility of reverse causation for several observed associations. Third, adjusted effect estimates were pooled despite differences in the covariates included in the original multivariable models, which may have resulted in residual confounding and reduced comparability across studies. Fourth, operational definitions and measurement approaches for several exposure variables, including dietary diversity, food insecurity, and ART adherence, differed across studies and may have contributed to the observed heterogeneity. Fifth, several pooled associations were based on only two studies and should therefore be interpreted cautiously. Sixth, a formal assessment of the certainty of evidence, such as GRADE, was not conducted. This was partly because the available evidence was predominantly observational and characterized by substantial clinical and methodological heterogeneity, variation in exposure definitions and measurement approaches, differences in covariate adjustment, and a limited number of studies contributing to several pooled associations. Consequently, the certainty of individual pooled estimates should be interpreted cautiously, particularly when estimates were based on only a small number of studies. Seventh, restricting the review to English-language publications may have introduced language bias. Finally, although publication bias was assessed, the small number of included studies limits the ability of statistical tests to reliably detect publication bias.

## **CONCLUSION**

Chronic energy deficiency remains an important nutritional concern among adults living with HIV in Ethiopia. The pooled prevalence was approximately 23%, but substantial between-study heterogeneity ( $I^2 = 94\%$ ) limits the extent to which this estimate can be interpreted as a uniform national prevalence. Several socioeconomic, dietary, and clinical characteristics were associated with CED, including unemployment, low wealth index, poor dietary diversity, household food insecurity, poor ART adherence, gastrointestinal symptoms, opportunistic infections, advanced WHO clinical stage, and lack of nutritional support. However, several pooled associations were based on only two studies, and differences in exposure definitions, reference categories, adjustment sets, and study designs limit comparability. Therefore, these findings should be interpreted as evidence of association rather than causation.

The findings support the continued integration of nutritional assessment, counseling, and support into HIV care, particularly for individuals experiencing socioeconomic vulnerability, food insecurity, inadequate dietary diversity, poor ART adherence, or advanced HIV disease. However, policy decisions should not be based solely on pooled estimates because of substantial heterogeneity and limited evidence for several associations. Further prospective, methodologically standardized studies are needed to strengthen the evidence base.

## Declarations

### Ethical approval and consent to participate

Not applicable

## Clinical trial

Not applicable

### Clinical trial number

Not applicable

## Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

### Conflict of interest

The authors declare no conflicts of interest among the authors or between the authors and institutions.

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## Author contributions

Alemayehu Tadesse was responsible for conceiving the research protocol, study design, literature review, data extraction, data analysis, interpretation of findings, and drafting the manuscript. Bethelhem Messele was responsible for data analysis and manuscript review. Solomon Niguse and Abinet Alemayehu were responsible for data extraction and quality assessment. All authors have read and approved the manuscript.

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## Data availability

The data extraction sheet, extracted data, PRISMA 2020 checklist, Detailed search strategy, PROSPERO Registration, and other supplementary files set is uploaded as supplementary information.

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## Figures

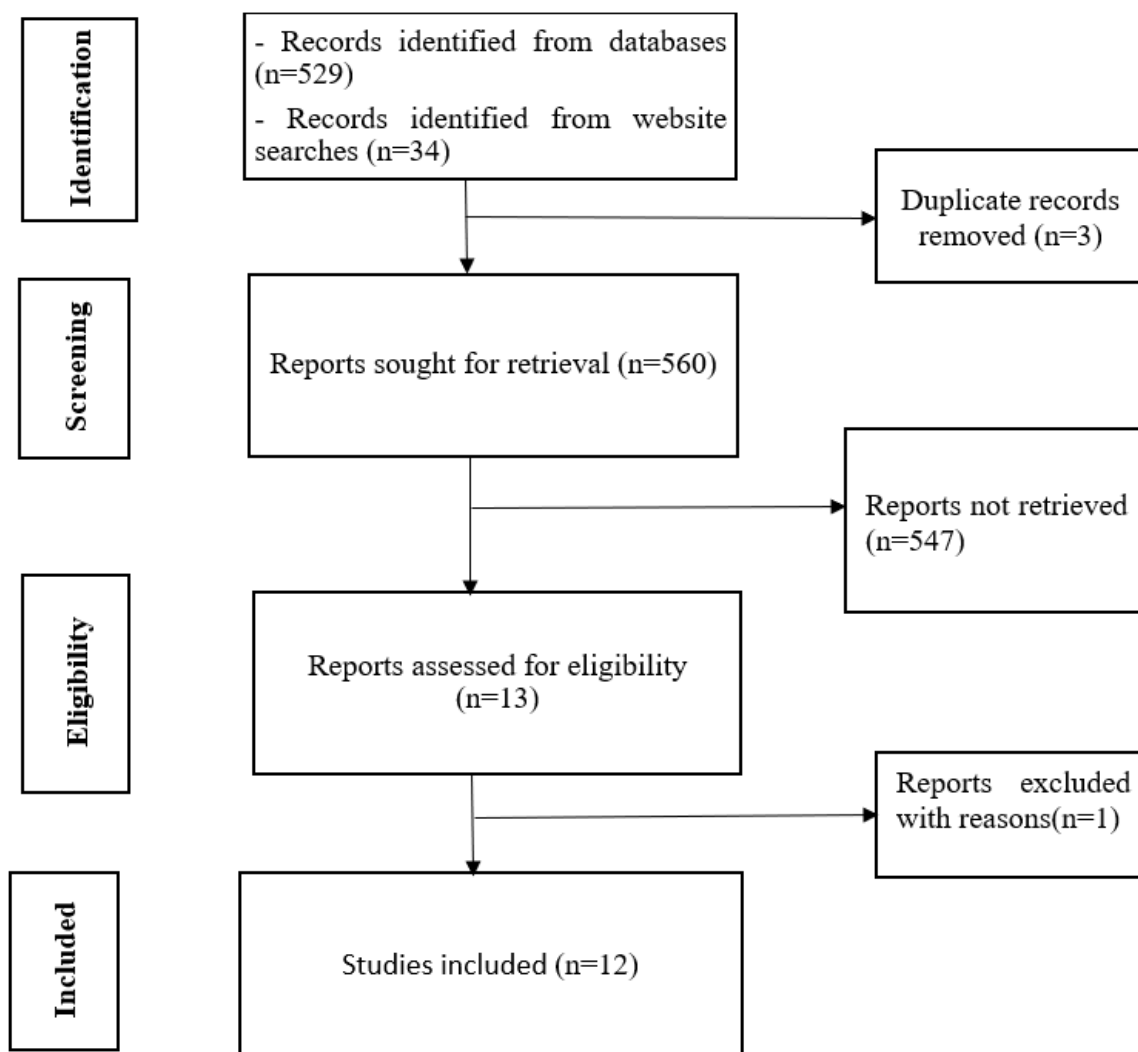


Figure 1

**Figure 1:** PRISMA flow diagram showing the identification, screening, eligibility assessment, and inclusion of studies in the systematic review and meta-analysis, Ethiopia, 2026.

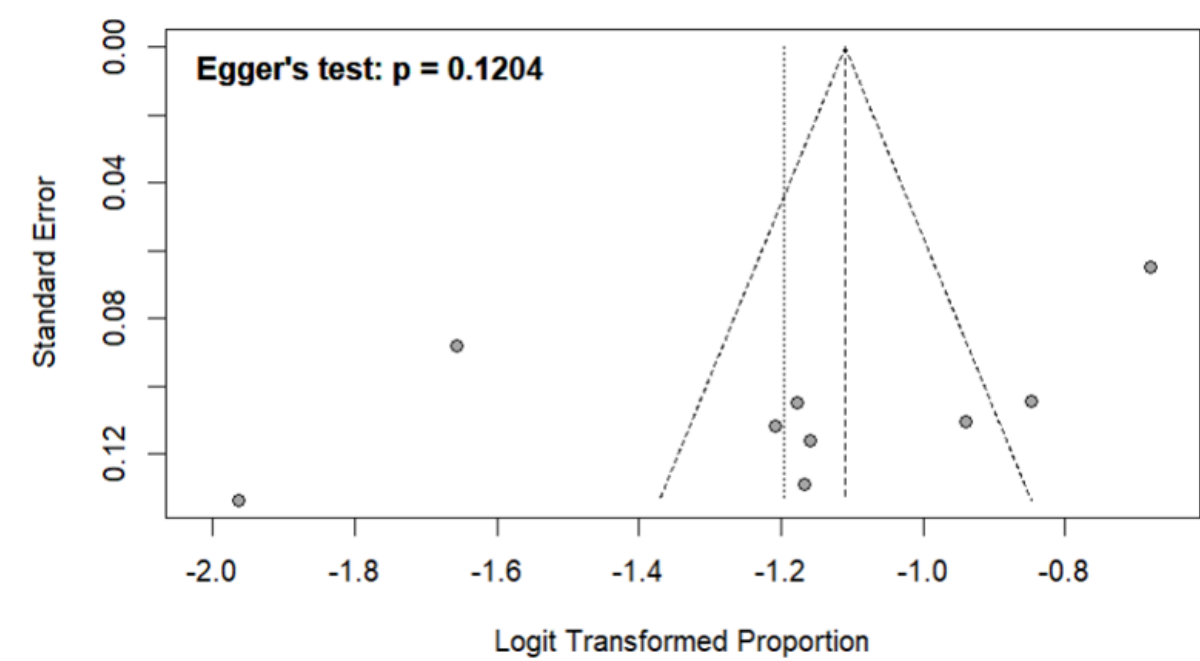


Figure 2

**Figure 2:** Funnel plot assessing potential publication bias among included studies, Ethiopia, 2026.

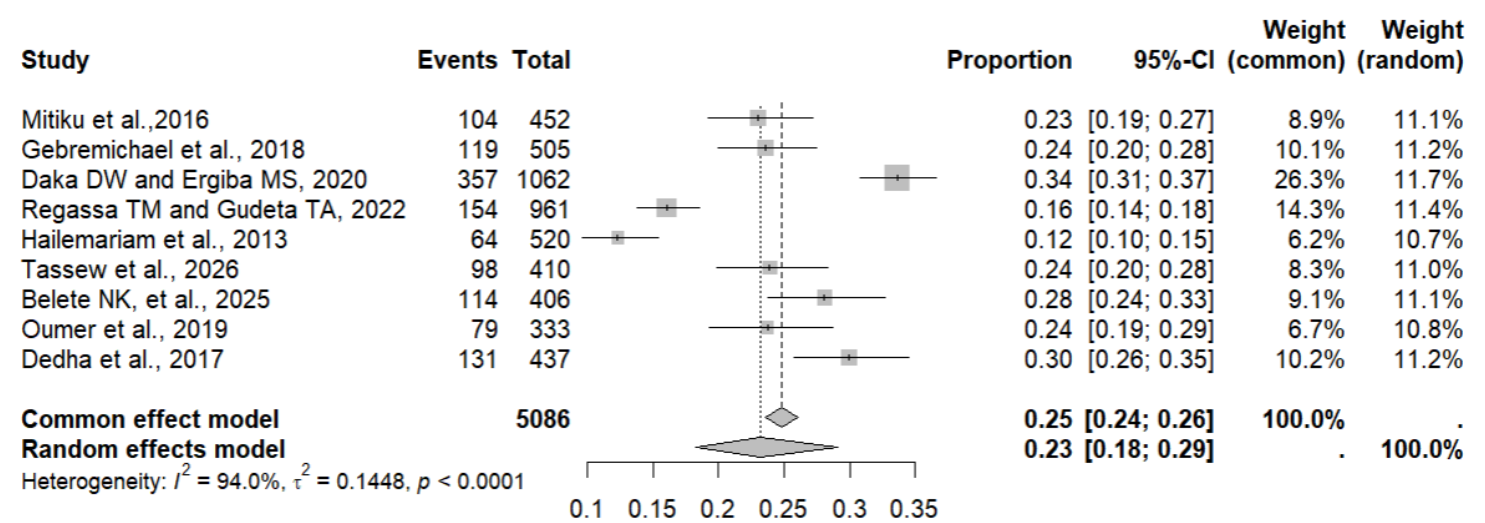


Figure 3

**Figure 3:** Forest plot showing pooled prevalence of chronic energy deficiency among adults living with HIV in Ethiopia, 2026.

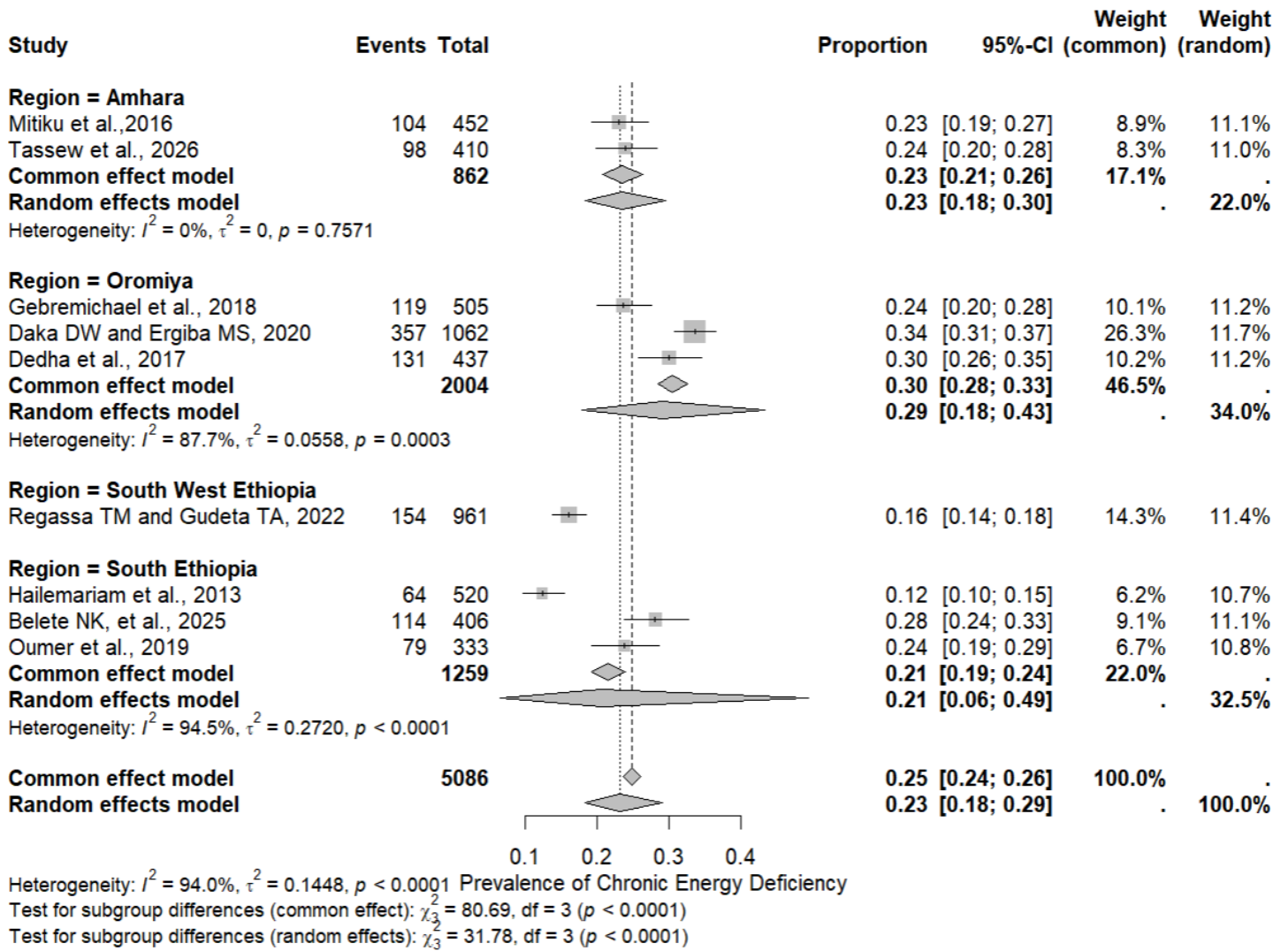


Figure 4

Figure 4: Subgroup analysis of the pooled prevalence of chronic energy deficiency by region in Ethiopia, 2026.

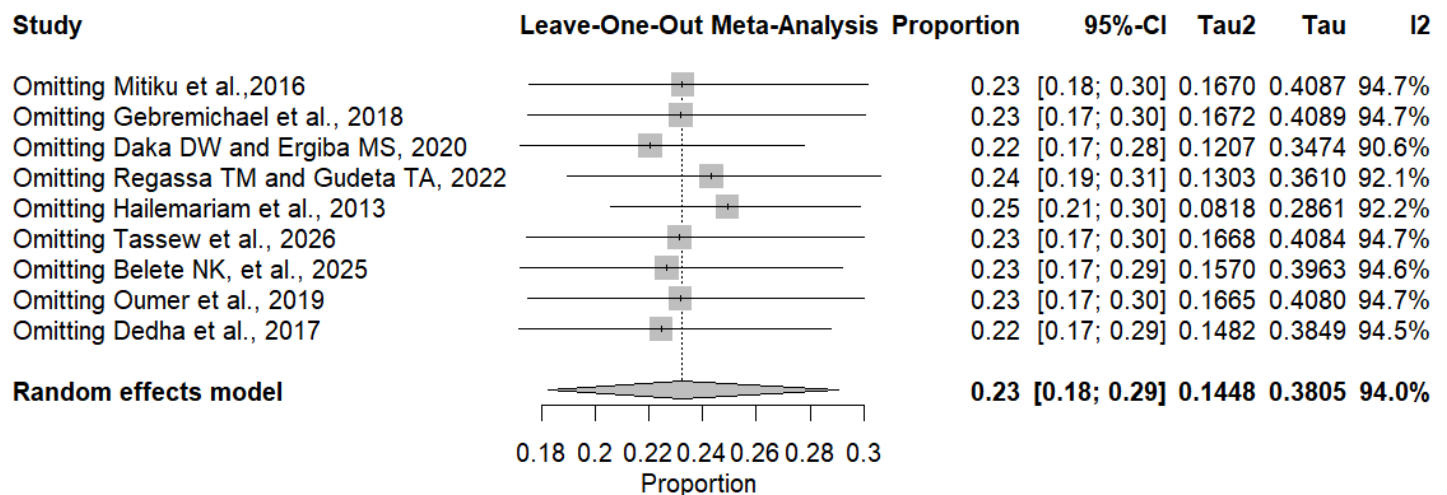


Figure 5

Figure 5: Sensitivity analysis assessing the influence of individual studies on pooled prevalence estimates, Ethiopia, 2026.

## Supplementary Files

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- [PRISMA2020Checklist.docx](#)
- [SupplementaryTableS1.docx](#)
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- [SupplementaryTableS3.xlsx](#)
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- [SupplementaryTableS5.docx](#)