

Effect of Health Belief Model-Based Nutrition Education Intervention on Nutritional Status of Pregnant Women in Rural Western Ethiopia: A Cluster Randomized Controlled Trial, 2026

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Abstract Maternal undernutrition affects 19.5% to 41.2% of pregnant women in Ethiopia, with limited progress from conventional programs. Despite the recognized benefits of theory-driven approaches, behavioral frameworks to guide maternal nutrition education interventions are not explored through interventional designs in severely affected rural pastoralist settings. This community-based, two-arm cluster-randomized controlled trial evaluated the effectiveness of a Health Belief Model-based nutrition education intervention in promoting nutritional status among 328 pregnant women (164 per arm) in rural Nuer Zone, Gambella Region, Western Ethiopia, from March to June 2026. A standard non-stretchable Middle-Upper Arm Circumference (MUAC) tape was used to assess nutritional status. Linear Mixed-Effects Models with Mediation analysis were employed to test intervention effects and pathways through Health Belief Model (HBM) constructs. At baseline, the prevalence of undernutrition (MUAC < 23 cm) was comparable between intervention and control groups (30.2% vs. 24.5%, respectively, $p = 0.285$), and mean MUAC values were similar (24.08 cm vs. 24.28 cm, $p = 0.285$). At endline, the intervention group showed a 1.334 cm increase in mean MUAC, compared with a 0.455 cm decline in controls (DiD = 1.789 cm, 95% CI: 1.485–2.093, $p < 0.001$). Likewise, undernutrition prevalence decreased from 30.2% to 5.6% in the intervention group, while it increased from 24.5% to 26.4% in controls, with changes in HBM constructs mediating 51.4% of the intervention effect. The HBM-based education intervention significantly improved nutritional status among pregnant women in rural western Ethiopia. Integrating theory-driven behaviour change approaches into Ethiopian maternal nutrition programs is recommended.

Keywords Cluster-Randomized Controlled Trial, Health Belief Model, Maternal Nutrition Education, MUAC, Nutritional Status, Rural Ethiopia.

Introduction

Undernutrition denotes insufficient intake of energy and nutrients needed to maintain health [1]. It manifests in four broad forms: wasting, stunting, underweight, and micronutrient deficiencies [1]. Pregnant mothers are more vulnerable to undernutrition owing to the increasingly high energy and nutrient needs of pregnancy [2]. Maternal undernutrition causes an estimated 20 million low birth weights [3] and 800,000 neonatal deaths each year [4]. It is associated with child stunting and wasting [5, 6] and poor cognitive and mental development, leading to suboptimal educational performance, limited employment opportunities, and lower economic productivity [7]. Moreover, it is associated with an increased lifelong risk of chronic diseases, including hypertension and diabetes [7]. Globally, over one billion adolescent girls and women suffer from undernutrition [8]. In developing countries, the prevalence of undernutrition among pregnant women ranges from 13% to 38% [9]. Iron deficiency anemia is a major contributor to maternal mortality, and nearly 3.1 million children die annually from consequences related to pregnancy undernutrition in these countries [4]. Sub-Saharan Africa and South Asia are severely affected by maternal undernutrition due to chronic micronutrient deficiencies [9], accounting for approximately 68% of the world's underweight adolescent girls and women and 73% of low birth weight deliveries [8].

Factors influencing the nutrition of pregnant women comprise multifaceted sociocultural and economic factors, causing disparate variation in the burden of undernutrition across geographical regions and countries [10]. Ethiopia made considerable efforts to improve maternal and child nutrition over the past decades. It adopted its first stand-alone National Nutrition Program (2008–2015) focused on improving the nutrition of mothers and children through scaled-up nutrition-

specific interventions [11]. Recognizing the need for multisector collaboration in promoting nutrition and attaining the Sustainable Development Goals (SDGs), Ethiopia developed its second National Nutrition Program in harmony with the country's Growth and Transformation Plan (GTP II: 2016–2020) to provide legal frameworks for mainstreaming nutrition into multisector strategies and programs, including the Nutrition-Sensitive Agriculture Strategy, National Food Security Strategy, National Health Sector Transformation Plan, National Food Fortification Program, and the National School Health and Nutrition Strategy [12]. The National Food and Nutrition Policy emphasized promoting access to diversified, nutritious foods for all citizens to break the vicious cycle of undernutrition and improve life expectancy [13]. Despite these efforts, the burden of undernutrition among Ethiopian pregnant women is high, varying from 19.5% to 41.2% [14], with rural areas heavily affected [15]. Systematic reviews showed that the pooled prevalence among pregnant women was 32% [16]. Similarly, studies revealed a high prevalence of inadequate dietary diversity practices (38.8% to 73.6%) among Ethiopian pregnant women [14, 17]. According to a case study review of implementation experience to improve maternal nutrition in Ethiopia, education and counseling provided through the routine health systems were ineffective in promoting nutrition behaviours [18].

Indeed, behavioral interventions are evaluated using theory in the context in which they occur to understand the drivers of behaviours and the process of change [19]. The Health Belief Model (HBM) is a social psychological theory that focuses on individuals' attitudes and beliefs to predict health behaviors [20]. According to this model, behavior change is driven by individuals' perceptions about health threats and their beliefs about benefits and barriers to undertaking prescribed health action [20].

HBM assumes that people are rational—they eliminate (reduce) risky health behavior when provided with adequate understanding of its consequences [20]. It conceptualizes that people are afraid of serious illnesses, and that adopting health-promoting behaviors reflects both a person's level of fear of perceived health threats and beliefs about the effectiveness of the recommended health behavior at an acceptable cost [20]. The model covers six cognitive constructs: perceived susceptibility to illness, perceived severity of illness and its consequences, perceived

benefits of health behavior, perceived barriers to adopting a behavior, perceived self-efficacy, and cues to action [20]. The HBM has proven effective in improving nutrition behaviours across populations. According to a study in Gujarat State, India, nutrition education based on the Health Belief Model significantly improved the nutritional status of pregnant women [21]. Unlike broader social-ecological models, the HBM provides a structured framework for designing practical, individualized counselling strategies delivered through community health workers (Figure 1).

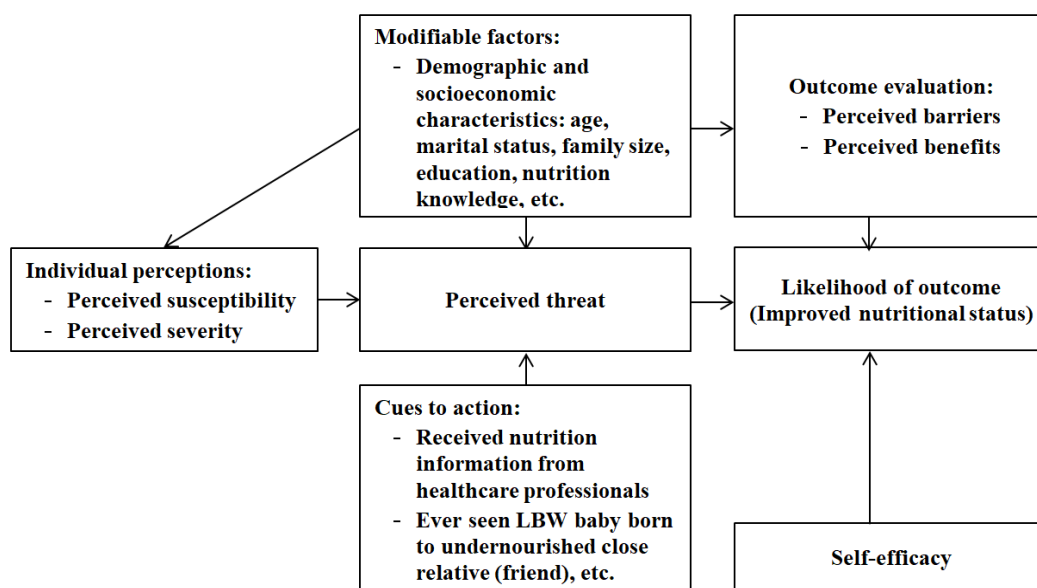


Figure 1. Theoretical Model for Promoting Nutrition of Pregnant Women Using the Health Belief Model [20]

Despite the recognized importance of theory-driven interventions, behavioural frameworks to guide maternal nutrition education in rural pastoralist settings of Ethiopia are not adequately explored through interventional designs. In addition, the existing nutrition programs in these settings lack rigorous evaluation. This trial aimed to evaluate the effectiveness of Health Belief Model-based nutrition education interventions in improving the nutritional status of pregnant women in rural western Ethiopia. The study will inform the design of contextually sensitive education programs to promote maternal nutrition in rural, low-resource settings.

Methods and Materials

Study Design and Setting

A community-based pretest-posttest cluster-randomized controlled trial was conducted to assess the effect of a nutrition education intervention based on the Health Belief Model on the nutritional status of pregnant women in Nuer Zone, Gambella Region, Western Ethiopia, from March to June 2026. The zone is a lowland rural setting (elevation 400–430 meters above sea level) where the population predominantly pursues an agro-pastoral livelihood, relying on mixed crop cultivation, livestock rearing, and fishing. It comprises five districts and 121 kebeles (the smallest

administrative units); one primary hospital, eight health centers, and 47 health posts. According to the 2026 projection, Nuer Zone has a total population of 206,598, of whom 53,922 are women of reproductive age, and 6,198 are pregnant women.

Participants Eligibility Criteria

The source population included all pregnant women residing in the Nuer zone, western Ethiopia. The study population was pregnant women in the selected districts. Women in their first or second trimester (confirmed gestational age ≤ 16 weeks) were eligible, thereby providing an adequate window to complete the intervention before delivery. Women of gestational age exceeding 16 weeks were excluded from the study.

Sample Size Determination

The sample size was calculated for the dietary diversity outcome using G*Power version 3.1.9.7 [22] for a two-sample t-test. At a 95% confidence level ($\alpha = 0.05$), power of 80%, effect size of 0.4, and an allocation ratio of 1:1, the sample size was 156. Considering the design effect of 2 and a 10% non-response rate, the sample size becomes 328 (164 participants per arm). The effect size was considered from a cluster-randomized trial conducted in the West Gojam zone of Ethiopia, which revealed a mean Dietary Diversity Score (DDS) of 5.4 ± 1.8 for the intervention group, in contrast to 4.5 ± 1.6 for the control group at the endline, resulting in a Cohen's d effect size of 0.4 [10]. The sample size was adequate for both the primary MUAC outcome and the secondary DDS outcome, with post-hoc power calculation confirming >99% power for MUAC and >90% power for DDS based on the observed effect sizes.

Sampling Procedures - Randomization

A multi-stage stratified sampling strategy was adopted. In the first stage, four of the five rural districts of Nuer Zone were selected using a pseudo-random number generator. In

the second stage, these four districts (namely Lare, Jikaw, Makuey, and Wanthoa) were stratified by population density (high vs. low) and health facility accessibility (high vs. low). Within each stratum, districts were randomly assigned to intervention or control arms using a computer-generated random sequence. This stratification ensured balance in key district-level characteristics between arms. In the third stage, 22 kebeles (20% of kebeles) were randomly drawn from each selected district using computer-generated random numbers. A household screening was carried out by health extension workers in these kebeles to identify eligible pregnant women and establish a sampling frame. To minimize cross-contamination, we selected non-adjacent kebeles within each district, with a minimum distance of 5 km between intervention and control clusters. Additionally, health extension workers were instructed not to discuss the intervention content with women in control kebeles (clusters). Within each kebele, eligible women were recruited via systematic random sampling from the sampling frame, with the sampling interval (k) calculated as the total number of pregnant women in the kebele divided by the required sample quota.

Blinding

Complete blinding of participants and intervention facilitators to group allocation was not logistically feasible owing to the overt nature of the educational sessions. Nevertheless, both arms were uninformed about the specific study hypotheses and the primary endpoint to reduce performance bias. Control group participants were told that they would receive the educational materials upon completion of the endline survey, rather than being explicitly designated as a "control group", thereby minimizing resentment or compensatory behavioral changes. Data collectors responsible for outcome measurement were strictly blinded to group allocation throughout the study.

Theoretical Framework

The intervention was designed using the Health Belief Model (HBM) as its foundational behavioral underpinning. The HBM postulates that the likelihood of adopting a health-protective behavior is determined by an individual's perception of threat (susceptibility and severity) and their evaluation of the recommended action (benefits versus barriers), along with self-efficacy and cues to action. The educational content targeted six core HBM constructs: perceived susceptibility to pregnancy-related undernutrition, perceived severity of its consequences, perceived benefits of adequate nutrition, perceived barriers to optimal eating practices, confidence in one's ability to change (self-efficacy), and environmental prompts for action (cues to action). HBM was selected for this intervention because it explicitly addresses the cognitive and perceptual factors most relevant to dietary behavior in low-resource settings, particularly perceived barriers (e.g., food access, cost, cultural taboos) and perceived severity (awareness of health consequences). It was hypothesized that the intervention would exert its effect on MUAC by first modifying these six core constructs, and this mediational pathway was formally tested using mediation analysis.

Description of the Intervention

Participants in the intervention arm were provided with a nutrition education session once monthly over three consecutive months. All educational materials (facilitator manuals, pictorial leaflets, brochures, and counseling cards) were developed in alignment with the latest dietary and nutrition guidelines from the World Health Organization, the Food and Agriculture Organization, and Ethiopia's Federal Ministry of Health [23-25]. The curriculum covered: the physiological consequences of maternal undernutrition; increased energy and nutrient demands during gestation; the short- and long-term health,

economic, and social repercussions of poor nutritional status for both the mother and offspring; the role of diverse, locally available, nutrient-dense foods in promoting adequate gestational weight gain and maintaining MUAC; culturally embedded food taboos and their harmful effects; proper food handling and hygiene; and the importance of adhering to iron-folic acid and iodized salt supplementation. Each monthly education session, lasting three hours, was delivered in the local Nuer language. Participatory adult-learning techniques, including moderated group discussions, brainstorming exercises, cooking demonstrations, and role-play scenarios, were employed to foster engagement and retention. The sessions were facilitated by four health professionals holding bachelor's degrees and two holding master's degrees, selected for their prior experience and fluency in the local dialect. They underwent a standardized five-day training workshop on the intervention protocol and facilitation methods. Additionally, community health extension workers, who received a one-day orientation, conducted biweekly home visits lasting 30-60 minutes to provide individualized nutrition counseling. During these visits, they helped women identify practical barriers to dietary improvement and reinforced problem-solving skills to strengthen self-efficacy. Endline data were gathered one month after the final group session to capture sustained changes in nutritional status. Women in the control group received routine antenatal care, which includes standard nutrition counseling on iron-folic acid supplementation and dietary diversity as per Ethiopia's national guidelines, but no structured, theory-based education sessions or home visits. They received full educational materials and were provided a condensed version of the education intervention after endline survey. Attendance was monitored at each group session, with a mean attendance rate of 89.7% (range: 78–95%) across the three sessions. Home visit

completion rates averaged 92.3% (range: 85–98%), with non-completion primarily due to women traveling to visit relatives or attending market days. The median home visit duration was 45 minutes (IQR: 35–55).

Fidelity of Intervention

The intervention fidelity was monitored and maintained according to the five-domain framework ('best practices') proposed by the National Institutes of Health Behavior Change Consortium [22]. These domains included: (1) standardizing the dose across all participants using a detailed session manual specifying activity timelines; (2) uniform facilitator preparation through a structured training syllabus; (3) direct observation of session delivery using supervisory checklists and session scripts; (4) gauging participant comprehension via pre- and post-session knowledge quizzes; and (5) verifying practical application of learned skills during the biweekly reinforcement visits. Supervisors independently completed fidelity checklists for 90% of the group education sessions (54 out of 60) and 85% of the home visits (102 out of 120). The mean fidelity score, expressed as the percentage of checklists executed as planned, was 87.3% (SD = 6.2) for group sessions and 85.6% (SD = 7.1) for home visits. To gauge inter-facilitator reliability, two supervisors concurrently evaluated a random 10% subset of sessions; the resulting Cohen's κ was 0.82 (95% CI: 0.74–0.89), denoting substantial agreement.

Measurement of Outcome Variable and Covariates

Nutritional Status, the outcome variable, was measured using a standard, non-stretchable Middle Upper Arm Circumference (MUAC) tape. MUAC is a reliable and simple tool used as a surrogate for Body Mass Index to monitor the nutritional status of pregnant mothers [26]. Trained data collectors took all measurements on women's left arms, strictly

adhering to WHO standardized anthropometric procedures [27]. A MUAC threshold of <23 cm was used to classify women as undernourished for descriptive purposes.

Health Belief Constructs were assessed using a 27-item Likert-scale questionnaire adapted from validated instruments [28, 29]. The subscales included perceived susceptibility (4 items), perceived severity (4 items), perceived benefits (4 items), perceived barriers (5 items), self-efficacy (4 items), and cues to action (6 items). Each item was scored from 1 (strongly disagree/very unlikely) to 5 (strongly agree/very likely). Construct-specific summary scores were computed and divided into tertiles, with the highest tertile reflecting a stronger presence of a belief. Higher perceived susceptibility, severity, benefits, self-efficacy, and cues to action are associated with a greater probability of achieving the desired behavioral outcome (normal nutritional status), whereas higher perceived barriers are linked with a lower likelihood of the outcome.

Household Food Insecurity was assessed using the standard Household Food Insecurity Access Scale (HFIAS), comprising nine occurrence and nine frequency questions to characterize household food access [30]. The occurrence (experience) of a food insecurity condition was scored 1, and non-occurrence was scored 0. Any household reported at least one or more food insecurity condition in the past four weeks was classified as food insecure.

Household Wealth Index was measured using the International Wealth Index (IWI) scale, adapted to suit the study setting and ensure discriminative power [31]. IWI scale is an asset-based index used to measure a household's economic status by assessing material well-being [31]. The tool comprised 22 questions covering household assets, housing quality, water source, and sanitation facilities. Of these, 20 binary questions with scores of 1 (Yes) and 0 (No) assessed the ownership of specified assets, while two

questions evaluated the quality of the household's water supply and the toilet facility, with scores of 1 (poor quality), 2 (medium quality), and 3 (good quality). As the IWI scale assigns equal scores for all assets, which may otherwise have different values, principal component analysis was performed to generate item weights, and the resulting scores were grouped into quintiles ranging from poorest to wealthiest.

Nutrition knowledge was assessed through an 11-item questionnaire covering basic maternal nutrition during pregnancy (e.g., recommended dietary diversity and eating patterns, iron-rich foods, and iodine sources), with a correct response assigned a score of 1 and an incorrect response a score of 0. Correct responses were summed to create a total knowledge score (ranging from 0-11), which was then categorized into tertiles, with the highest tertiles representing good nutrition knowledge, the middle tertiles medium nutrition knowledge, and the lowest tertiles poor nutrition knowledge.

Additional Covariates: Data were also collected on maternal age, marital status, educational attainment, occupation, household size, living arrangement, obstetric history (parity, gravidity, and antenatal care attendance), husband's education and occupation, home garden availability, and household cash decision-making.

Data Collection Tools and Procedures

Data were gathered using a pretested, structured interviewer-administered questionnaire. The instrument encompasses sections: sociodemographic characteristics, obstetric history, HBM constructs, nutrition knowledge, eating habits and food taboos, household food insecurity, and wealth index. A dedicated section recorded all relevant anthropometric measurements. Four data collectors (holding bachelor's degrees in public health nutrition) and two supervisors (holding master's degrees) were recruited and

intensively trained on methods and procedures. Data collection occurred in three phases: (1) a pre-study household survey to identify eligible participants and create the sampling frame, (2) baseline data collection, conducted immediately before the intervention, and (3) endline data collection, conducted one month after the final education session to assess outcome variables (MUAC, DDS, HBM constructs, and nutrition knowledge).

Data Quality Assurance

To guarantee semantic equivalence, the questionnaire was translated from English into Nuer and then independently back-translated by two language specialists. A five-day practical training was provided for data collectors and supervisors, covering interview techniques, anthropometric standardization, and ethical conduct. The full questionnaire was pretested on 5% of the target sample in a neighboring non-study district. Reliability and validity assessments yielded satisfactory metrics: internal consistency (Cronbach's α) for the HBM subscales ranged from 0.72 to 0.89 (threshold ≥ 0.7); content validity (Lawshe's Content Validity Ratio) ranged from 0.81 to 0.95 (threshold ≥ 0.78); and face validity (Cohen's κ) ranged from 0.65 to 0.78 (threshold ≥ 0.60). Confirmatory factor analysis confirmed the dimensional structure of the HBM scales, with goodness-of-fit indices between 0.91 and 0.95 (target ≥ 0.9). During fieldwork, data collectors reviewed each questionnaire for completeness prior to leaving the participant's household, while supervisors conducted daily random spot-checks for accuracy and consistency. For MUAC, inter-observer reliability was evaluated through duplicate measurements on a subsample; intra-class correlation coefficient reached 0.93 (exceeding the benchmark: 0.90).

Statistical Analysis

Data were entered via the Kobo Toolbox platform on Android devices and exported to

IBM SPSS Statistics 25 for analysis. Descriptive statistics: means, standard deviations, frequencies, and percentages were computed to summarize participant characteristics. Normality of continuous variables was assessed using Kolmogorov-Smirnov tests. Baseline comparability between the intervention and control groups was examined using independent t-tests for continuous variables and chi-square tests for categorical variables.

To estimate the intervention's effect on nutritional status while properly accounting for the clustered and repeated-measures nature of the data, a Linear Mixed-Effects Model (LMM) with restricted maximum likelihood estimation was employed. The model acknowledged the hierarchical data structure: repeated MUAC observations (baseline and endline) nested within individual women, who were themselves nested within kebeles (clusters). The fixed-effect component of the model included: time (baseline vs. endline), group (intervention vs. control), and the two-way interaction between time and group. This interaction term represented the difference-in-differences estimator, i.e., the average change in MUAC from baseline to endline in the intervention group relative to the control group and constituted the primary parameter of interest. The model was adjusted for covariates to control for potential residual confounding and improve precision: maternal age, educational level, household wealth quintile, family size, parity, and baseline MUAC. Random intercepts were incorporated at both the participant level (to account for within-subject correlation across the two time points) and the cluster level (to account for between-kebele variability).

Model Diagnostics and Missing Data:

Model assumptions were verified by plotting standardized residuals against fitted values to check homoscedasticity and inspecting Q-Q plots to assess normality of the random effects. The Intra-cluster Correlation Coefficient (ICC)

was derived from the variance components to quantify the proportion of total variance attributable to between-cluster differences. Multicollinearity among continuous predictors was examined using Variance Inflation Factors, all of which remained below 2.0, indicating no collinearity. Influential outliers were screened using Cook's distance; no value exceeded the conventional threshold of $4/n$, suggesting that individual observations did not unduly influence estimates. Missing data were minimal, accounting for less than 5% of observations. A comparative analysis of baseline characteristics between participants with complete follow-up and those lost to follow-up revealed no statistically significant differences, supporting the assumption that data were missing at random conditional on the observed covariates. Under this assumption, the LMM with maximum likelihood estimation provides unbiased and efficient parameter estimates. All analyses were conducted on an intention-to-treat basis, with participants analyzed according to their original cluster allocation regardless of intervention adherence. Missing outcome data were handled using restricted maximum likelihood estimation within the LMM framework, which provides unbiased estimates under the missing-at-random assumption. To evaluate the intervention's effect on theoretical mediators, change scores (endline - baseline) were computed for each of the HBM constructs. Independent t-tests were used to compare mean change scores between the intervention and control groups. Difference-in-differences (additional change in the intervention group vs. controls) was calculated for each construct, along with 95% CIs and p-values, allowing measurement of the extent to which the intervention modified health beliefs.

Mediation Analysis: To formally test whether changes in HBM constructs mediated the intervention effect on MUAC, a mediation analysis was conducted using a bootstrapping approach with 5,000 resamples: Hayes

PROCESS macro v4.0 for SPSS [32]. Because causal mediation requires temporal precedence, the intervention group (X) was modeled as the independent variable, baseline HBM construct scores as mediators (M), and endline MUAC as the outcome (Y), adjusting for baseline values of both the respective HBM construct and baseline MUAC. This approach establishes temporal ordering (intervention → endline mediator → endline outcome, conditional on baseline values) and is consistent with modern recommendations for longitudinal mediation. Given that six HBM constructs were tested as individual mediators, a conservative Bonferroni correction was applied for the individual mediator tests ($\alpha = 0.05/6 = 0.0083$) to control Type I error. Individual mediation effects with p-values below 0.0083 were considered statistically significant. The combined model (all six mediators simultaneously) was evaluated at $\alpha = 0.05$, as it represents a single omnibus test of the mediation pathway.

Effect Reporting: Adjusted mean differences (β coefficients) were presented with their 95% confidence intervals and corresponding p-values derived from Wald tests. To facilitate clinical interpretation, Estimated Marginal Means (EMMeans) were computed for MUAC in each group at each time point, adjusted for all covariates. Within-group and between-group contrasts were compared using pairwise comparisons with Least Significant Difference (LSD)

adjustment. A two-sided significance level of $\alpha = 0.05$ was applied to hypothesis tests.

Results

Socioeconomic Characteristics and Comparability

The baseline socioeconomic and nutritional profiles of the intervention and control groups were comparable across all measured characteristics (Table 1). A total of 328 pregnant women participated in the study (164 in each arm). The mean age was 28.1 years (SD 4.6), mean household size was 5.3 members (SD 2.0), and baseline MUAC was nearly identical for the intervention and control groups (24.08 cm vs. 24.28 cm). Educational attainment, occupational distribution, household food insecurity, and nutrition knowledge were similarly balanced between arms, with no statistically significant differences ($p > 0.05$ for all comparisons). The mean gestational age was 13.8 weeks (SD 3.2) in the intervention group and 14.6 weeks (SD 3.5) in the controls. Follow-up completion was high in both groups: 162/164 (98.8%) in the intervention and 159/164 (97.0%) in the control arm. Loss to follow-up was due to relocation (intervention: $n = 1$; control: $n = 3$) and withdrawal of consent (intervention: $n = 1$; control: $n = 2$), with no losses due to adverse events. Baseline characteristics did not differ between completers and non-completers ($p > 0.05$), supporting the assumption of missing data at random (Table 1).

Table 1. Baseline Socioeconomic Characteristics of Participants and Comparability by Study Group in Nuer Zone, Gambella Region, Western Ethiopia, 2026

Characteristics	Category	Intervention	Control	P value
		N (%)	N (%)	
Age (years)	Mean ($\pm$ SD)	28.3 (4.5)	27.9 (4.8)	0.487
Age at first marriage	Mean ($\pm$ SD)	18.4 (3.8)	18.1 (4.2)	0.499
Family size	Mean ($\pm$ SD)	5.2 (1.9)	5.4 (2.1)	0.739
Baseline MUAC (cm)	Mean ($\pm$ SD)	24.08 (1.71)	24.28 (1.68)	0.285
Marital status	Married & live together	57 (34.8)	55 (33.5)	0.937
	Separated	56 (34.1)	55 (33.5)	
	Divorced	51 (31.1)	54 (32.9)	

Education of respondent	Secondary & above	86 (52.4)	85 (51.8)	0.917
	Primary (1–8)	42 (25.6)	40 (24.4)	
	No formal education	36 (22.0)	39 (23.8%)	
Occupation of respondent	Employee	39 (23.8)	44 (26.8)	0.254
	Merchant (trader)	41 (25.0)	36 (22.0)	
	Farmer	39 (23.8)	51 (31.1)	
	Daily laborer	45 (27.4)	33 (20.1)	
Education of husband	Secondary & above	86 (52.4)	74 (45.1)	0.295
	Primary (1–8)	34 (20.7)	45 (27.4)	
	No formal education	44 (26.8)	45 (27.4)	
Occupation of husband	Employee	40 (24.4)	38 (23.2)	0.168
	Merchant	49 (29.9)	34 (20.7)	
	Farmer	37 (22.6)	40 (24.4)	
	Daily laborer	38 (23.2)	52 (31.7)	
Nutrition knowledge	Low	72 (43.9)	77 (47.0)	0.833
	Medium	47 (28.7)	46 (28.0)	
	High	45 (27.4)	41 (25.0)	
Household food security	Food secure	88 (53.7)	79 (48.2)	0.32
	Food insecure	76 (46.3)	85 (51.8)	
Household wealth status	Poorest	33 (20.1)	31 (18.9)	0.96
	Poorer	32 (19.5)	30 (18.3)	
	Middle	23 (14.0)	26 (15.9)	
	Richer	39 (23.8)	39 (23.8)	
	Richest	37 (22.6)	38 (23.2)	
Dietary diversity	Inadequate	124 (75.9)	120 (73.0)	0.542
	Adequate	40 (24.1%)	44 (27.0)	
Cash decision maker	Husband	41 (25.0)	43 (26.2)	0.876
	Wife	72 (43.9)	66 (40.2)	
	Joint	44 (26.8)	47 (28.7)	
	Others	7 (4.3)	8 (4.9)	
Living arrangement	Nuclear	112 (68.3)	107 (65.2)	0.613
	Joint/Extended	49 (29.9)	51 (31.1)	
	Others	3 (1.8)	6 (3.7)	
Home garden available	No	35 (21.3)	28 (17.1)	0.337
	Yes	129 (78.7)	136 (82.9)	
Parity	Nulipara	26 (15.9)	24 (14.6)	0.9
	1–3	89 (54.3)	88 (53.7)	
	≥4	49 (29.9)	52 (31.7)	
Mean gestational age	Mean (±SD)	13.76	14.61	0.1

SD: Standard Deviation, MUAC: Middle-Upper Arm Circumference

Effect of Nutrition Education on Maternal Nutritional Status

At baseline, the prevalence of undernutrition (MUAC < 23 cm) was comparable between intervention and control groups (30.2% vs. 24.5%, respectively; $p = 0.285$), and mean MUAC values were similar (24.08 cm and 24.28 cm, $p = 0.285$). At the endline, the intervention group demonstrated marked improvement, with undernutrition prevalence declining to 5.6% and mean MUAC increasing to 25.41 cm (SD 1.65). Conversely, the control group showed deterioration, with undernutrition rising to 26.4% and mean MUAC declining to

23.83 cm (SD 1.06). The between-group differences were significant for both prevalence (20.8 percentage points, $\chi^2 = 28.9$, $p < 0.001$, number needed to treat = 5) and continuous MUAC (1.587 cm, $p < 0.001$). The Difference-in-Differences (DiD) estimate of 1.789 cm (95% CI: 1.485–2.093, $p < 0.001$) confirms that the intervention conferred a substantial protective effect on maternal nutritional status, effectively reversing the declining trend observed in the control group. These findings indicate that the intervention was associated with meaningful improvements in nutritional status, supporting its potential for broader implementation (Table 2).

Table 2. Differences in Mean MUAC Measurement by the Group over the Study Period in Nuer Zone, Gambella Region, Western Ethiopia, 2026

Variable	Study Period	Intervention	Control	t-test	Mean Difference	P-value
		Mean $\pm$ SD	Mean $\pm$ SD		(Intervention – Control) $\pm$ SE	
MUAC (cm)	Baseline	24.080 $\pm$ 1.711	24.282 $\pm$ 1.679	–1.071	–0.203 $\pm$ 0.189	0.285
	End line	25.414 $\pm$ 1.648	23.827 $\pm$ 1.063	10.23	1.587 $\pm$ 0.155	<0.001
	Difference (EL – BL)	1.334	–0.455	–	1.789 (DiD)	< 0.01

BL: Baseline, EL: End line, SD: Standard Deviation, SE: Standard Error

Within and Between Group Changes in Health Belief Model Constructs

Table 3 presents the within-group changes in HBM constructs from baseline to endline. The intervention group demonstrated substantial positive changes across all six constructs, with the largest improvements observed in perceived benefits (+5.97), perceived barriers (–4.79), and cues to action (+3.94). In contrast, the control group showed minimal changes, with small increases in

perceived benefits (+3.37) and self-efficacy (+1.14), and a slight decline in perceived susceptibility (–0.21). The difference-in-differences (DiD) between groups was highly significant for all constructs (p -values < 0.001), with the largest between-group difference observed for perceived barriers (–4.49, 95% CI: –4.95 to –4.03) and perceived severity (+3.38, 95% CI: 2.88–3.88). Note: A negative sign signifies a reduction in score.

Table 3. Changes in Mean HBM Constructs from Baseline to Endline by Study Group in Nuer Zone, Gambella Region, Western Ethiopia, 2026

Construct	Intervention	Control	Mean Difference (I – C)	95% CI	P-value
Perceived Susceptibility	2.57	–0.21	2.78	(2.31, 3.25)	<0.001
Perceived Severity	3.78	0.4	3.38	(2.88, 3.88)	<0.001
Perceived Benefits	5.97	3.37	2.6	(2.14, 3.06)	<0.001

Perceived Barriers	-4.79	-0.30	-4.49	(-4.95, -4.03)	<0.001
Self-efficacy	2.4	1.14	1.26	(0.86, 1.66)	<0.001
Cues to Action	3.94	0.32	3.62	(3.05, 4.19)	<0.001

Mediation of HBM Constructs in Intervention's Effect on MUAC

To examine the mechanisms through which the intervention improved MUAC, mediation analysis was conducted using endline HBM construct scores as mediators and endline MUAC as the outcome, adjusted for baseline values of both the respective HBM construct and baseline MUAC (Table 4). The total intervention effect on MUAC was 1.789 cm ($p < 0.001$). All six HBM constructs emerged as significant mediators, with perceived barriers reduction mediating the largest proportion of the total effect (43.6%, indirect effect = 0.78, 95% CI: 0.51–1.07), followed by

perceived severity (39.1%, indirect effect = 0.70, 95% CI: 0.42–1.02) and cues to action (34.1%, indirect effect = 0.61, 95% CI: 0.35–0.91). When all six mediators were included simultaneously in the model, the combined indirect effect was 0.92 (95% CI: 0.68–1.18), accounting for 51.4% of the total effect. This suggests that changes in health beliefs and self-efficacy explain approximately half of the intervention's impact on maternal nutritional status, with the remaining effect potentially operating through other unmeasured pathways or direct behavioral changes (Table 4).

Table 4. Mediation of HBM Constructs in the Intervention's Effect on MUAC Among Pregnant Women in Nuer Zone, Gambella Region, Western Ethiopia, 2026

Mediator (Change Score)	Direct Effect	Indirect Effect	Total Effect	Proportion Mediated	95% CI
Perceived Susceptibility	1.21	0.58**	1.79***	32.40%	(0.31, 0.89)
Perceived Severity	1.09	0.70***	1.79***	39.10%	(0.42, 1.02)
Perceived Benefits	1.23	0.56**	1.79***	31.30%	(0.28, 0.85)
Perceived Barriers (↓)	1.01	0.78***	1.79***	43.60%	(0.51, 1.07)
Self-Efficacy	1.34	0.45*	1.79***	25.10%	(0.18, 0.72)
Cues to Action	1.18	0.61***	1.79***	34.10%	(0.35, 0.91)
Combined Model	0.87	0.92***	1.79***	51.40%	(0.68, 1.18)

* P -value < 0.05 , ** P -value < 0.01 , *** P -value < 0.001 , Reduction (↓)

Linear Mixed-Effects Model

Table 5 presents the fully adjusted Linear Mixed-Effects Model examining the intervention effect on MUAC. The intervention conferred a significant net improvement in MUAC ($\beta = 1.789$, 95% CI: 1.485–2.093, $p < 0.001$). The random effects components revealed that 3.2% of the

total variance in MUAC was attributable to between-cluster (kebele) differences, 61.9% was due to between-participant variability, while 34.8% reflected within-participant changes over time. Model building was guided by AIC/BIC, and the final model demonstrated the best fit (AIC = 2086.4, BIC = 2135.6) (Table 5).

Table 5. Linear Mixed-Effects Model for the Effect of Nutrition Education Intervention on MUAC Among Pregnant Women in Nuer Zone, Gambella Region, Western Ethiopia, 2026

Fixed Effects	β Coefficient	95% CI	SE	p-value
Intervention Effects				
Time (End line vs. Baseline)	-0.455	(-0.662, -0.248)	0.106	<0.01
Group (Intervention vs. Control)	-0.202	(-0.573, 0.169)	0.189	0.285
Intervention effect	1.789	(1.485, 2.093)	0.155	<0.01
Covariates				
Baseline MUAC (cm)	0.961	(0.942, 0.980)	0.01	<0.01
Random Effects	Variance	ICC		
Between-cluster (kebele)	0.056	0.032		
Between-participant (intercept)	1.081	0.619		
Random Slope for Time	0.016	0.009		
Residual	0.608	0.348		
Model Fit				
AIC	2086.4			
BIC	2135.6			

AIC: Akaike Information Criterion, BIC: Bayesian Information Criterion, CI: Confidence Interval, ICC: Intra-class Correlation Coefficient, SE: Standard Error

Note: Values are regression coefficients (β) from a mixed-effects linear regression model. The model was adjusted for baseline variables. Random effects included between-cluster (kebele) variance, between-participant intercept variance, random slope for time, and residual variance. All VIFs were <2.0, confirming no problematic multicollinearity.

Discussion

This community-based cluster-randomized controlled trial evaluated the effect of a nutrition education intervention based on the Health Belief Model on the nutritional status of pregnant women in rural western Ethiopia. The intervention in this study resulted in a statistically significant improvement in MUAC, with a net Difference-in-Differences (DiD) of 1.789 cm ($p < 0.01$) between the intervention and control groups. The observed improvement in MUAC is noteworthy in the context of maternal nutrition in rural Ethiopia. MUAC is a validated indicator of nutritional status during pregnancy, and the positive change observed in the intervention group, contrasted with a decline in the controls, suggests that the intervention may have helped women maintain or improve their nutritional reserves during a critical period. This pattern of improvement in the intervention group alongside deterioration in the control group is

particularly meaningful, as it indicates that the intervention not only promoted positive change but may have also protected against the typical nutritional decline in resource-limited settings. The decline in MUAC observed in the control group (0.455 cm) is consistent with findings from the West Gojam trial, where control group participants experienced a reduction in MUAC over the course of pregnancy [33]. This pattern likely reflects the increased physiological demands of pregnancy coupled with inadequate dietary intake, which is common in resource-limited settings. The intervention appears to have not only prevented this decline but also reversed it, resulting in a net difference of 1.789 cm in MUAC. This protective effect is particularly meaningful, as it suggests that theory-driven nutrition education helped women maintain nutritional reserves during a period of heightened vulnerability. The 1.789 cm net improvement in MUAC corresponds to a

clinically meaningful reduction in undernutrition prevalence. Using the standard MUAC cut-off of <23 cm, the intervention reduced the proportion of undernourished women from 30.2% at baseline to 5.6% at endline, whereas the control group experienced an increase in undernutrition prevalence from 24.5% to 26.4%. This translates to a Number Needed to Treat (NNT) of 5 to prevent one case of maternal undernutrition. These findings suggest the intervention helped women cross the clinical threshold of adequate nutritional reserves. These findings are broadly consistent with previous studies in Ethiopia. A recent systematic review reported that nutrition education interventions were associated with improvements in MUAC among pregnant women, with community-based theory-driven approaches showing larger effects [34]. A cluster-randomized trial in West Gojam of Amhara region reported a significant reduction in undernutrition prevalence among intervention group participants [33]. Similarly, the finding is consistent with a quasi-experimental study in Southern Afghanistan that evaluated the effectiveness of an HBM-based educational intervention on iron-folic acid (IFA) supplement intake among pregnant women [35]. This consistency of findings across settings: highland agricultural zones, urban areas, and our lowland agro-pastoral context suggest that theory-based nutrition education may be a transferable strategy for improving maternal nutrition in Ethiopia.

The mediation analysis revealed that changes in HBM constructs collectively accounted for approximately half (51.4%) of the intervention effect on MUAC improvement. This finding supports the theoretical framework underpinning the intervention and offers insights into which beliefs may be most important for driving behavior change. Perceived barriers reduction emerged as the strongest mediator, accounting for 43.6% of the total effect. This is consistent

with the HBM's theoretical premise that perceived barriers are among the strongest predictors of behavior change. In rural Ethiopia, barriers to adequate nutrition during pregnancy are pervasive, including limited food availability, economic constraints, cultural food taboos, and competing household demands. Our intervention appears to have been particularly effective in addressing these barriers through practical problem-solving during home visits, where women received individualized support to identify and overcome obstacles to dietary improvement. Perceived severity was the second strongest mediator (39.1%), suggesting that enhancing women's understanding of the serious consequences of undernutrition for themselves and their offspring was an important pathway for influencing nutritional status. The present findings contrast with those of a cluster-randomized trial in Southeast Ethiopia, which found no significant indirect effects through distal mediators including dietary diversity, food security, and nutrition knowledge, whereas our analysis demonstrated a significant indirect effect through proximal HBM constructs [36]. This discrepancy suggests that theory-anchored psychological beliefs are more sensitive mediators of intervention-induced change than behavioral proxies. Second, the present results align with evidence from Tanzania and Malawi, where perceived barriers, particularly cost, accessibility, and cultural constraints, and perceived severity were consistently identified as key determinants of dietary practices and adherence [37]. Together, these comparisons indicate that while distal behavioral indicators may fail to capture mechanistic pathways, proximal HBM constructs, particularly perceived barriers and perceived severity, consistently emerge as critical mediators of maternal nutrition behaviors across sub-Saharan African settings. Several methodological strengths and limitations warrant consideration. This cluster-

randomized controlled design provides strong evidence for causality, and the high fidelity of intervention delivery (87-88%) strengthens confidence in the internal validity of the trial. The inclusion of mediation analysis represents a methodological strength, providing insights into the mechanisms of change that are often lacking in nutrition intervention studies. However, some limitations should be acknowledged. The study was conducted in a single zone, which may limit generalizability to other regions of Ethiopia with different socioeconomic, cultural, and ecological contexts. The relatively short follow-up period (three months) precludes assessment of long-term sustainability of the intervention effects. The inability to blind participants is an inherent limitation of educational interventions, and self-reported measures of HBM constructs may have introduced social desirability bias. The mediation analysis, while informative, is observational and subject to unmeasured confounding; the use of change scores does not fully address the issue of temporal precedence, and measurement error in self-reported mediators may have attenuated the estimated indirect effects.

Implications for Practice and Policy

The findings suggest that theory-driven, community-based nutrition education may be an effective strategy for improving maternal nutrition in rural Ethiopia. The observed mediating role of HBM constructs, particularly perceived barriers and perceived severity, offers practical guidance for intervention design. Programs that incorporate strategies to identify and address practical barriers to dietary improvement, while also communicating the serious consequences of undernutrition in culturally appropriate ways, may be more effective than generic nutrition education. The involvement of health extension workers in delivering the intervention aligns with Ethiopia's Health Extension Program and demonstrates the

potential of this platform for delivering effective nutrition interventions at scale.

Conclusions

This trial provides evidence that a Health Belief Model-based nutrition education intervention was associated with significant improvement in the nutritional status of pregnant women in rural western Ethiopia. The intervention effect appeared to be partially mediated through changes in health beliefs, particularly perceived barriers and perceived severity. These findings support the integration of theory-driven behavior change approaches into maternal nutrition programming in Ethiopia and similar settings. However, further research is needed to confirm these findings in other populations and settings and to evaluate long-term sustainability and cost-effectiveness.

Data Sharing

Data are available on reasonable request from the corresponding author.

Conflict of Interest

The authors declare that they have no competing interests.

Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki [38], and the Ethiopian National Research Ethics Review Guidelines of 2014 [39]. Ethical approval was obtained from the Institutional Review Board of the Gambella Peoples National Regional State Health Bureau. Additional administrative permissions were obtained from the Nuer Zone Health Office and the respective district health authorities. All eligible women were given comprehensive information about the study's purpose, procedures, potential risks, and anticipated benefits. Written informed consent was obtained from each participant before enrolment; for women unable to read or write, an impartial community witness was present throughout the consent process. Participants

were explicitly informed that their involvement was entirely voluntary and that they could discontinue participation at any point without any negative repercussions for their routine healthcare. To protect confidentiality, all data were anonymised using unique participant identification codes, and electronic data were stored on password-protected, encrypted computers accessible only to the core research team. Women identified as undernourished (MUAC < 23 cm) or presenting with other health concerns were immediately referred to the nearest primary health facility for appropriate management. As an ethical gesture of beneficence, the control group was offered the complete educational materials and a condensed version of the intervention after the end line survey had been finalized. The study findings will be disseminated to the participating communities, local health authorities, and the regional health bureau to guide evidence-based maternal nutrition programming.

References

- [1]. Lecerf JM, Andreelli F. Undernutrition. *Malawi Medical Journal*. 2022;18(4):185–205.
- [2]. Most J, Dervis S, Haman F, Adamo KB, Redman LM. Energy Intake Requirements in Pregnancy. *Nutrients*. 2019;11(8):1812.
- [3]. WHO. Global Nutrition Monitoring Frameworks: Operational Guidance for Tracking Progress in Teeting targets for 2025 [Internet]. Vol. IV, World Health Organization. Geneva: World Health Organization; 2017. p. 77. Available from: <http://apps.who.int/iris/bitstream/handle/10665/259904/9789241513609eng.pdf;jsessionid=82B08433379C3E3E69B3F8D4F2690C34?sequence=1%0Aw> www.who.int/nutrition

Authors' Contribution

The authors' contributions were evaluated based on the following components: Conception and Design, Execution (Data Acquisition), Analysis and Interpretation, and Manuscript Preparation (Drafting and Finalization). The corresponding author contributed to all of these phases of the research project, while other authors contributed to Conception and Design, Interpretation, and Manuscript Revision and agreed to publication in this journal.

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- [4]. World Bank Group. Addressing Maternal Nutrition in the Context of Primary Health Care: A Review of Completed World Bank Group-Funded Projects Targeting Maternal Nutrition in Sub-Saharan Africa From 1997 to 2018 in A Primary Health Care Context. Washington DC, USA; 2021.
- [5]. Ntenda PAM. Association of Low Birth Weight with Undernutrition in Preschool-aged Children in Malawi: Cross-Sectional Study. *Nutrition Journal*. 2019;18(51):1–15. Available from: <https://doi.org/10.1186/s12937-019-0477-8>
- [6]. Jana A, Dey D, Ghosh R. Contribution of Low Birth Weight to Childhood Undernutrition in India: Evidence from the National Family Health Survey 2019–2021. *BMC Public Health*. 2023;23(1336):1–

14. Available from: <https://doi.org/10.1186/s12889-023-16160-2>
- [7]. USAID. Multi-Sectoral Nutrition Strategy (2014-2025). Washington DC; 2014. p. 11. Available from: https://www.usaid.gov/sites/default/files/documents/1867/USAID_Nutrition_Strategy_5-09_508.pdf
- [8]. UNICEF. Undernourished and Overlooked: A Global Nutrition Crisis in Adolescent Girls and Women. UNICEF Child Nutrition Report Series. New York, NY 10017, USA; 2023. Available from: [https://www.unicef.org/media/135791/file/Executive_summary_\(English\).pdf](https://www.unicef.org/media/135791/file/Executive_summary_(English).pdf)
- [9]. Tafara L, Bikila H, Feyisa I, Desalegn M, Kaba Z. Prevalence of Undernutrition and Associated Factors Among Pregnant Women Attending Antenatal Care Service in Public Hospitals of Western Ethiopia. *PLoS One*. 2023;18(1):e0278180. Available from: <http://dx.doi.org/10.1371/journal.pone.0278180>
- [10]. Demilew YM, Alene GD, Belachew T. Effect of Guided Counseling on Dietary Practices of Pregnant Women in West Gojjam Zone, Ethiopia. *PLoS One*. 2020;15(5):e0233429. Available from: <http://dx.doi.org/10.1371/journal.pone.0233429>
- [11]. Ethiopian Ministry of Health. National Nutrition Strategy of Ethiopia. FMOH, Ethiopia; 2008. p. 14. Available from: [https://extranet.who.int/nutrition/gina/sites/default/files/ETH 2008 National Nutrition Strategy_1.pdf](https://extranet.who.int/nutrition/gina/sites/default/files/ETH%2008%20National%20Nutrition%20Strategy_1.pdf)
- [12]. Ministry of Health of Ethiopia. National Nutrition Program (2016-2020). Published. 2016. p. 88. Available from: www.unicef.org/ethiopia/National_Nutrition_Programme.pdf
- [13]. Ethiopian Ministry of Health. Ethiopian Food and Nutrition Policy. 2018;(November):40.
- [14]. Gebremichael MA, Belachew Lema T. Dietary Diversity, Nutritional Status, and Associated Factors among Pregnant Women in their First Trimester of Pregnancy in Ambo District, Western Ethiopia: Community-based Cross-Sectional Study. *Nutrition and Metabolism Insights*. 2023;16:1–12.
- [15]. CSA. Ethiopian Demographic and Health Survey. Report. 2016.
- [16]. Zewude SB, Beshah MH. Undernutrition and Associated Factors among Pregnant women in Ethiopia. A Systematic Review and Meta-analysis. *Frontiers in Nutrition*. 2024;11:1347851.
- [17]. Jemal K, Awol M. Minimum Dietary Diversity Score and Associated Factors among Pregnant Women at Alamata General Hospital, Raya Azebo Zone, Tigray Region, Ethiopia. *Journal of Nutrition and Metabolism*. 2019.
- [18]. Saldanha LS, Buback L, White JM, Mulugeta A, Mariam SG, Roba AC, et al. Policies and Program Implementation Experience to Improve Maternal Nutrition in Ethiopia. *Food and Nutrition Bulletin*. 2012;33(Suppl 2):27–50.
- [19]. The Improved Clinical Effectiveness Through Behavioral Research Group. Designing Theoretically-Informed Implementation Interventions. *Implementation Science*. 2006;1(4):1–8.
- [20]. Green EC, Murphy EM, Gryboski K. The Health Belief Model. *Wiley Encyclopedia of Health Psychology*. 2020;(May 2022):211–4.
- [21]. Daniel S, Gnanaraj G, Sharmin E. Effect of Nutrition Education among Pregnant Women with Low Body Mass Index: A Community-based Intervention. *International Journal of Community Medicine and Public Health*. 2016;3(11):3135–9. Available from: <http://www.ijcmph.com>
- [22]. Bellg AJ, Resnick B, Minicucci DS, Ogedegbe G, Ernst D, Borrelli B, et al. Enhancing Treatment Fidelity in Health Behavior Change Studies: Best Practices and Recommendations from the NIH Behavior Change Consortium. *Health Psychology*. 2004;23(5):443–51.
- [23]. WHO. Maternal, Infant, and Young Child Nutrition. Vol. 266. 2018.
- [24]. Ministry of Health of Ethiopia. Ethiopian Food-Based Dietary Guidelines. ILRI Editorial and Publishing Service. 2022;1(March):108.
- [25]. FAO and FHI 360. Minimum Dietary Diversity for Women: A Guide for Measurement. Rome; 2016. Available from: <http://www.fao.org/3/a-i5486e.pdf>
- [26]. Miele MJ, Souza RT, Calderon IMP, Feitosa F, Leite DF, Rocha Filho E, et al. Proposal of MUAC as a Fast Tool to Monitor Pregnancy

Nutritional Status: Results from a Cohort Study in Brazil. *BMJ Open*. 2021;11(5):1–11.

[27]. Ethiopian Federal Ministry of Health. Adolescents, Maternal, Infant and Young Child Nutrition Guideline (2016-2020). 2016;(June):68.

[28]. Abotchie PN, Shokar NK. Cervical cancer screening among college students in Ghana knowledge and health beliefs. *International Journal of Gynecological Cancer*. 2009;19(3):412–6.

[29]. Gasparotto J. Cue to Action: Do they Results in Beliefs and Behavioural Intention Change in Women? 2007. 1–149 p.

[30]. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide (Version 3). Washington, DC Food Nutrition Technology. 2007;(August):Version 3.

[31]. Smits J, Steendijk R. The International Wealth Index (IWI). 2013;(2):1–29. Available from: <http://www.ru.nl/nice/workingpapers>

[32]. Hayes AF. Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-based Approach. 2nd editio. New York: The Guilford Press. 2018.

[33]. Demilew YM, Alene GD, Belachew T. Effect of Guided Counseling on Nutritional Status of Pregnant Women in West Gojjam Zone, Ethiopia: A Cluster-randomized Controlled Trial. *Nutrition Journal*. 2020;19(38):1–12.

[34]. Chanie SD, Tilahun WM, Menber Y, Wasihun Y, Gebreegziabher ZA, Andualem Z, et al. The Effect of Nutrition Education and

Counseling on the Nutritional Status of Pregnant Women in Ethiopia, 2025: A Systematic Review and Meta-analysis. *Journal of Health, Population, and Nutrition*. 2025;44(334):1–18.

[35]. Stanikzai MH, Le CN, Ezadi Z, Sayam H, Shohaimi S. Effectiveness of a Health Belief Model-Based Educational Intervention on Iron-Folic Acid Supplement Intake Among Pregnant Women in Southern Afghanistan: A Quasi-Experimental Study. *International Journal of Women's Health*. 2026;(July):1–14.

[36]. Beressa G, Whiting SJ, Belachew T. Effect of Nutrition Education Integrating the Health Belief Model and Theory of Planned Behavior during Pregnancy on Gestational Weight Gain and Birth Weight in Southeast Ethiopia using Complex Analyses. *BMC Pregnancy and Childbirth*. 2025;25(196):1–15.

[37]. Ali S. How Anaemia Perceptions Shape Dietary Diversity Practice in Pregnancy: A Health Belief Model Study in Tanzania. 2025;9(1):86–95.

[38]. World Health Organization. World Medical Association Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects. *Bulletin of World Health Organization*. 2001;79:373–4.

[39]. Ethiopian Federal Ministry of Science and Technology. Ethiopian National Research Ethics Review Guideline [Internet]. 2014. p. 13. Available from:

<https://www.google.com/search?client=firefox-b-d&q=National+Reserach+Ethics+Guicdeline>