

The Effect of Nutrition Education on Hemoglobin Levels among Pregnant Women: A Systematic Review and Meta-Analysis

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Submitted: 01-06-2025
Accepted: 12-11-2025
Published: 01-12-2025

Citation:

Qotrunnada, M. Z., Fauzi, A. Y., & Mahmudiono, T. (2025). The Effect of Nutrition Education on Hemoglobin Levels among Pregnant Women: A Systematic Review and Meta-Analysis. *Media Gizi Kesmas*, 14(2), 332-344.
<https://doi.org/10.20473/mgk.v14i2.2025.332-344>

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ABSTRACT

Background: Pregnancy-related anemia is an important women's health issue with worldwide implications due to its impact on the mother and baby. Nutritional education can increase hemoglobin (Hb) levels through improving women's knowledge and encouraging more frequent consumption of iron-rich foods and taking folic acid. Despite this, the results that have been produced in previous research are inconsistent. In this regard, the aim of the present systematic review with meta-analysis is to establish whether nutritional counseling is among the best intervention approaches to boost Hb levels and prevent anemia.

Objective: To study the effect of nutrition education on hemoglobin levels of pregnant women.

Methods: The present systematic review and meta-analysis adhere to PRISMA 2020 guidelines. A literature review was conducted using the main databases from January 2019 to April 2025. Seven relevant studies were comprised of RCTs and quasi-experimental designs. A statistical analysis using MD of hemoglobin level in the intervention group compared to the control, along with 95% CI was also calculated. The data was analyzed with the aid of a random effect model. Heterogeneity was tested with the aid of the I^2 statistics and Cochran's Q test. Sensitivity analysis was also conducted to check the robustness of the pooled data after harassing the study by eliminating each one individually.

Results: The meta-analysis included seven studies, including a total of 1,120 pregnant participants. Combined data indicated that the subjects in the nutrition education group had a greater increase in the level of their hemoglobin compared to those in the control group, with a mean difference of 0.73 g/dL (95% CI=0.62–0.84; $p<0.00001$). There was marked heterogeneity ($I^2=94\%$). Additional research demonstrated the efficacy of an integrated approach in this case, counselling bolstered by digital and visual tools over other methods employing only lectures (MD=0.85 g/dL; 95% CI=0.71–0.99). In this case, lectures yielded weaker results (MD=0.52 g/dL; 95% CI=0.41–0.64). Sensitivity analysis verified that the aggregated data were consistent enough that no single study had a disproportionate impact on the overall findings.

Conclusion: Nutrition education, with systematic nutrition sessions and practice, has been found to be more effective in improving hemoglobin levels in pregnancy as compared to disorganized education. In light of the continued burden of anemia in pregnancy, the inclusion of systematic and comprehensive nutrition education into antenatal care programs holds the main key to reducing this problem.

Keywords: Dietary Intake, Hemoglobin Levels, Nutrition Education, Pregnant Women

INTRODUCTION

Nutrition is one of many factors affecting the health of a pregnant woman and her fetus. During pregnancy, women are at risk of developing

anaemia, which is defined as a deficit of red blood cells or haemoglobin. Because of its profound effects on women's and children's health, anaemia in pregnancy has been recognised as a global health

issue (Ge *et al.*, 2025). Individually and collectively, iron, folic acid, and vitamin B12 are considered essential, and their deficiencies may explain decreased hemoglobin levels (Tamirat *et al.*, 2022). According to a report, approximately 40% of pregnant women worldwide suffer from anemia. The prevalence varies across countries, with recent data showing rates of 35.2% in Malaysia, 29.6% in Ethiopia, 46.3% in Nepal, 48.9% in Indonesia, and 37.5% in Egypt. The high incidence of anemia remains a significant challenge in developing countries.

At a recent stage, previous research has shown that nutritional status in pregnancy is mainly influenced by the limited diversity of food, lack of nutrition education, and low economic levels (Putra and Sulastri, 2024). The lack of essential micronutrients is mainly attributed to inadequate consumption of iron-containing foods like red meat, liver, and leafy green vegetables, and poor vitamin C intake, which has an important enhancing role in absorption of the non-heme form of iron (Abd Elhaliem and Zwain, 2022). In addition, an absence of regular nutritional education and negligible participation by healthcare personnel can influence women's awareness of and compliance with healthy eating practices during pregnancy (Anggraini *et al.*, 2024).

Pregnancy-associated anemia is also associated with increased risks for mothers and fetuses. Symptomatic women are generally very fatigued, are at higher risk of labor complications, and have a greater chance of postpartum complications. At fetal level, this situation may result in delayed fetal growth and low birth weight as well as retarded development, which might also impact the future learning capacity of the child (Desta *et al.*, 2019). Multiple factors are linked with anemia; these factors include also poor diet, in particular low intake of iron and vitamins, infections such as malaria or parasitic worms, short pregnancy interval, and low income, which prevents to have access to nutritious food and health care services (Hofmeyr & Manyame, 2017).

Cultural and behavioral influences are contributing factors in the prevalence of anemia. Conventional dietary prohibitions for pregnancy restrict iron-containing foods. In addition, the internal deficiency of nutrition and lack of access to information on nutrition with dietary restriction increase anemia (Saragih, 2022). Addition of health education, behavior change strategies, and culturally sensitive components is required to address food limitations (Aden *et al.*, 2023).

Good education will teach them the importance of iron for women in pregnancy and give a few light diets, with uncertain indications (Vaivada *et al.*, 2017). Low levels of education frequently lead to the issues of dietary control and family health being considered as insignificant, which in turn

makes the fight against anemia more difficult. A comprehensive health and nutrition education that is comprehensive will lead to an increase in the awareness of mothers, thus the adoption of efficient preventive measures that will contribute to the decline of the rate of anemia-related problems in pregnancy eventually (Tolossa *et al.*, 2020). There is a report of pregnancy related anemia which states that the condition has been causing various harmful effects to the health of the mother such as the possibility of miscarriage, premature birth, infections resulting from obstruction, very low fetal development, as well as the increase in the mother's risk for infections and bleeding (Feyisa, Siu, and Bai, 2025). Nurses and doctors can only deliver the nutrition education that leads to the iron supplements among pregnant women to be the main reason for the performance of a healthy diet during pregnancy, as revealed by the empirical research. Structured, evidence-based nutrition programs can significantly reduce the prevalence of anemia during pregnancy (Atomei *et al.*, 2022). In light of the aforementioned context, the aim of this study is to conduct a systematic review and meta-analysis of the impacts of nutrition education on the diversity of the diet among pregnant women. The findings of this research are expected to provide solid scientific evidence to policymakers and health professionals for the development and implementation of more specific and effective nutritional intervention strategies for pregnant women (Engidaw *et al.*, 2025).

METHODS

Study Design and Reporting

This systematic review and meta-analysis were performed using the 2020 PRISMA Guidelines for Methodology for Systematic Reviews and Meta-Analyses as guiding principles for the approach in documenting the methodology used and to assist with future study replication. Nonetheless, none of the constituent parts of the research derived the tables, owing to which the rest of the study was still aligned to the PRISMA statement, especially concerning awareness, analysis, engagement, and recruitment parts of the study. This research aims to assess the impact of nutrition education on the haemoglobin levels of pregnant women and to evaluate the impact of the intervention and the various methods of delivery employed. The PRISMA analysis provides the study design and all subsequent parts of the analysis, along with the inclusion criteria. The aim of this review was to summarize the available evidence on the effects of practitioner dietary recommendations on hemoglobin levels in antenatal women and to evaluate the consistency of findings across strategies and settings.

Search Strategy

In the period leading up to this review, data were obtained from PubMed and retrieved through Scopus for the years ranging from January 1, 2019, to March 30, 2025. The developed search strategy integrated both MeSH terms and free text terms, supplemented with “AND” and “OR.” Subsequent database searches focused on PubMed.

("Nutrition Education"[MeSH] OR "Health Education" OR "Dietary Counseling" OR "Nutrition Intervention") AND ("Pregnant Women"[MeSH] OR "Pregnancy" OR "Antenatal Care" OR "Maternal Health") AND ("Hemoglobin"[MeSH] OR "Anemia, Iron-Deficiency"[MeSH] OR "Iron Deficiency" OR "Anemia") AND ("Randomized Controlled Trial" OR "Quasi-experimental Study" OR "Clinical Trial").

Scopus and its related databases have developed a specific parallel search syntax, which I used for my search. Only full articles accessible online and in English or Indonesian were selected. Other published studies related to the included studies and their relevant reviews were also reviewed for additional research.

Each reference obtained is imported into EndNote 21's Reference Management tool. Duplicate records are automatically removed and then manually checked. Two independent reviewers screened the titles and abstracts for relevance, followed by full-text screening against eligibility criteria. Discrepancies were resolved through consensus. The selection process was documented and illustrated using the PRISMA 2020 flow diagram.

Eligibility Criteria

Studies were included in this review if they met the following criteria: (1) enrolled pregnant women at any gestational age and reported sufficient participant characteristics such as maternal age, trimester of pregnancy, and health status; (2) implemented a structured nutrition education program as the main intervention, either as individual counseling, group sessions, home visits, or digital/mobile-based approaches; (3) provided measurable hemoglobin (Hb) outcomes both before and after the intervention; and (4) adopted an experimental design, specifically a Randomized Controlled Trial (RCT) or a quasi experimental study with a defined comparison group. Only original peer-reviewed articles published between 2019 and 2025 in English or Indonesian were included. Studies were excluded if they were literature reviews, conference proceedings, qualitative research, or did not present quantitative hemoglobin data, as well as those without accessible full text or that combined nutrition education with pharmacologic or fortification interventions, not isolating the effect of education.

For RCTs, studies were required to describe in detail the randomization process, including sequence generation and group allocation methods, and to include both an intervention and a control group. The intervention group received structured nutrition education sessions focusing on dietary improvement, iron-rich food intake, and adherence to Iron Folic Acid (IFA) supplementation, often incorporating interactive counseling, audiovisual materials, or mobile-based communication. The control group typically received standard antenatal care or routine maternal health education without a nutrition-specific component. Participant inclusion criteria generally consisted of healthy pregnant women aged 18–40 years, in the first or second trimester, with either normal hemoglobin levels or mild anemia. Exclusion criteria most commonly included multiple pregnancies, gestational diabetes, hypertension, pre-existing hematologic or chronic disease, and any obstetric complications that could independently affect hemoglobin levels. In contrast to individual randomization, quasi-experimental studies assign participants to communities, health facilities, or other geographic clusters. However, all studies have a clear "control" group that receives conventional maternal care. Such studies allow for the assessment of the impact of nutrition education implementation in a "real-world" or "field" project, while maintaining an organized comparison between the intervention and control groups.

In personalized studies, the duration of each intervention ranged from six weeks to twelve months, depending on the methodology, rigor, and number of repetitions of each training component. Most interventions were delivered by health workers such as midwives, nurses, and nutritionists, who had undergone specific training for the project. Training components could include personalized contact, the use of mobile apps, text messages, or multimedia modules aimed at knowledge and acceptance of behaviours. To assist with comprehension and to aid in carrying out the steps, the instructional materials integrated visuals, illustrations, poetry anthologies, and culture-specific menu planning templates.

Most interventions rely on the theories of behaviour change, like the Health Belief Model and the Theory of Behavioral Therapy, to enhance motivational factors, self-efficacy, and adherence to recommended behaviours regarding diet and supplements. The communication, interventions, and the subsequent reinforcement for behaviour change, desired behaviour change in particular, are built on the frameworks which are many of which are customised for the individual needs of the mothers. It should be pointed out that this review focused on those studies that, in their qualitative and quantitative research, thoroughly outlined and defined their aims, goals, and participant outcomes.

Data Extraction

Two reviewers systematically and independently extracted data from each study to assess their reliability and consistency. Using a data extraction spreadsheet designed for this purpose in Excel, the reviewers organised both qualitative and quantitative datasets. Each article was read in its entirety and logically coded by both reviewers through a collaborative, line-by-line analysis. The extraction datasets were scrutinised in order to ascertain the missing or controversial data sets which were resolved by agreement. This was done in this manner to ensure that the resolved approach was consistent and unbiased and was within the outlined boundary for PRISMA 2020 which offers guidelines. The data artifacts abstracted included: (1) the surname of the first author and the corresponding year of publication, (2) the nationality of the author, (3) type of study-RCT, quasi-experimental RCT, or quasi-experimental clinical trial, (4) sample size in total and by groups, (5) participant data relevant to maternal age, stage of pregnancy, and any other indicators of anemia or general health, (6) all components and elements of the nutrition program including its content, total duration, frequency of sessions, method of delivery, that is, individual or group sessions, home visits, or digital platform, and the professional title of the participant, such as traditional birth attendant, nurse, nutritionist, (7) guiding principles applied for example, health belief model or theory of expected behavior, (8) explanation of the control group and the standard of antenatal care or advice given, and (9) outcome variables as stated.

Quantitative synthesis requires the extraction of specific numerical data on hemoglobin concentrations for the intervention and control groups. This results in datasets for mean hemoglobin levels before and after the intervention and their standard deviations (SD) for the sample size (n), as well as available mean differences (ΔHb , g/dL). Studies documenting changes in hemoglobin values before and after the intervention were recorded, and those recording only group-level means were entered into the database with different values for separate pre- and post-intervention intervals. When outcome data were available, tables and figures from studies listed with hemoglobin values were taken without conversion, as hemoglobin is mostly available in grams per deciliter (g/dL).

An Excel spreadsheet was constructed for the collected quantitative information, which was then exported to Review Manager v5.4 for meta-analysis. In RevMan, standardized means from the control and intervention groups were used to calculate Weighted Mean Differences (WMDs) and 95% CIs (using a random effects model) for the RevMan analysis. Forest plots associated with intervention effect sizes (and direction) across studies. EndNote 21 software was utilised to prepare

the references, ensuring data integrity. It organises references, manages included/excluded studies, and confirms that the extracted datasets are properly linked to the original datasets. Comparisons between the EndNote library and the Excel extraction spreadsheet were made to facilitate overlap and accuracy of included data. This collection is organized and conducted in a step-by-step manner. All the study characteristics, intervention information, and quantitative outcomes for statistical synthesis were extracted, forming the basis of the forest model in the results section.

Statistical Analysis

Data for the meta-study were analyzed using RevMan (Review Manager), version 5.4. Like other studies, this study aimed to determine the impact of nutrition education on maternal hemoglobin (Hb) levels in the study group, while comparing them with prenatal levels in the control group. Means, along with Standard Deviations (SDs), and sample sizes (n) for the treatment and control groups were calculated for each study separately as part of this meta-study, and these data were entered into RevMan. For study outcomes where the intended outcome was hemoglobin level and was given in continuous, interval form under a variable system, the Mean Difference (MD) method was used, and results were expressed in grams per deciliter (g/dL). All studies measuring hemoglobin levels used the same conventional units, thus ensuring agreement. In this case, 95% Confidence Intervals (CIs) were used to indicate the range of each variable. There was no need to culturally transform or homogenize the data before the first step of the designed study.

A fixed effects model combined with the inverse variance (IV) method is used to estimate the pooled mean difference between studies. This model works on the basis that all studies in question are concerned with the same phenomenon. Each study is weighted according to the inverse of its mean, with studies with larger sample sizes and smaller standard errors being given higher weights. The results of individual studies and the overall pooled estimate are displayed in a forest plot. Studies are represented by dots, which convey their significance, while diamond shapes represent the pooled estimate and its confidence interval.

Assessment of statistical heterogeneity of studies was performed using the Cochran's Q test (chi-square test) and the I^2 value, which is the percentage of total 'non-random' variation between studies. Heterogeneity measures were categorized as low ($I^2 < 25\%$), moderate ($25-75\%$), or high ($I^2 > 75\%$). In cases of high heterogeneity, included studies were analyzed using descriptive assessments of the population, time, and intervention, as well as the method used as characteristics of the study population. Sensitivity analysis was used to assess

the statistical significance of the estimates by analyzing the results from each study. Statistically significant results were recorded with a two-sided p-

value<0.05, indicating a pooled analysis. The results as well as all analyses, were derived from the data directly imported into RevMan for processing.

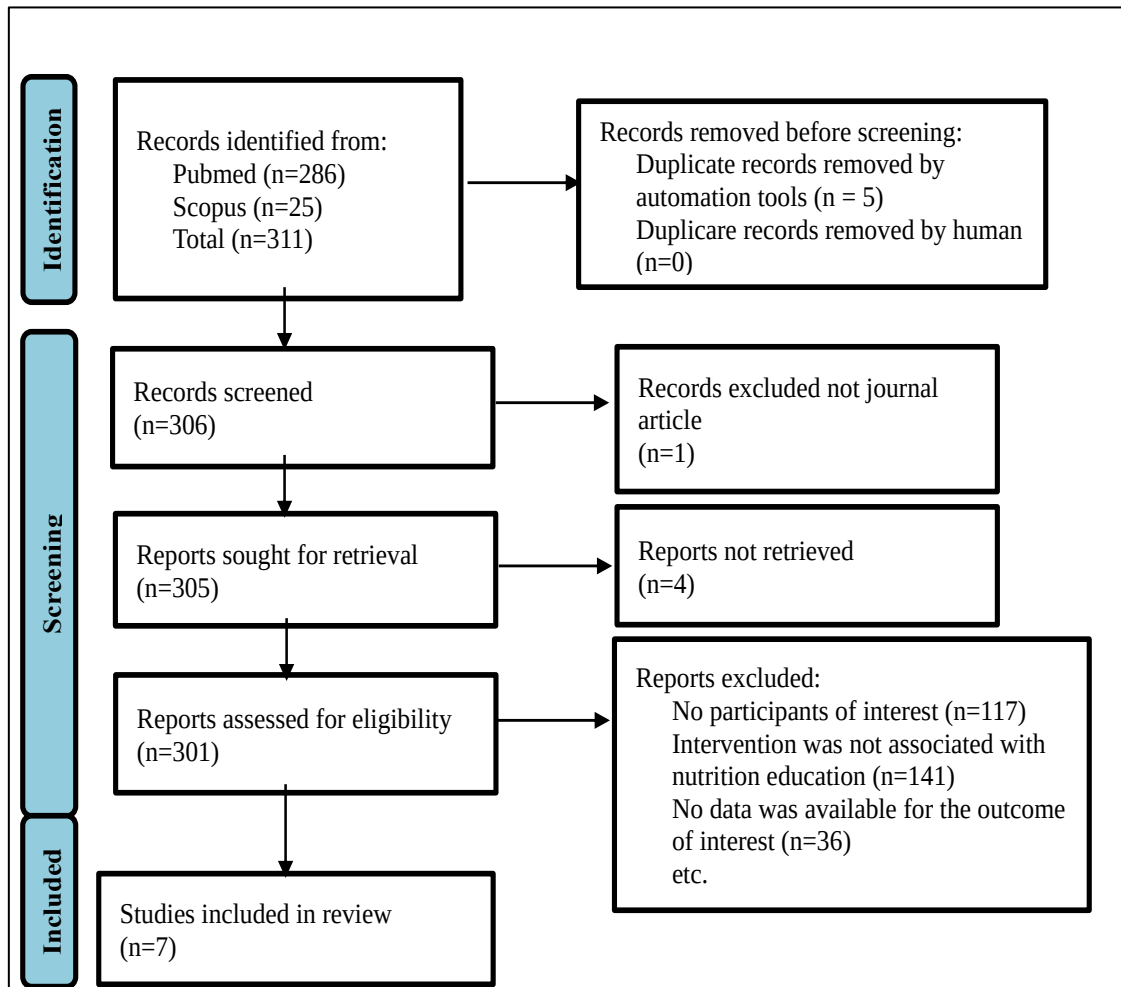


Figure 1. Prisma Flow Diagram

RESULTS AND DISCUSSION

In total, seven research studies were identified that fulfilled the inclusion criteria. All examined the effect of nutritional counseling on maternal hemoglobin concentrations during pregnancy. Analysis of the study designs revealed that four studies were Randomized Controlled Trials (RCTs) and three were quasi-experimental studies. Overall, the body of evidence consistently addressed the impact of nutrition education on maternal hemoglobin levels during pregnancy. The findings of this literature review are presented in the form of summaries and key points from each selected article, organized in a structured table. This systematic review/meta-analysis employs a narrative synthesis method to group similar extracted data based on outcome measures, aiming to address the research question. Anemia during pregnancy is increasingly recognised as a serious public health issue, particularly due to its close association with the nutritional status of the mother

(Stephen et al., 2018). Inadequate dietary habits are the main reasons for the iron deficiency in pregnant women. Eating ready-made foods, fried foods, or drinking tea or coffee after the meal may make the situation worse by blocking iron absorption (Raut and Hiwale, 2022). The issue of maternal anemia should receive great attention because this condition is linked with an increase in the occurrence of pregnancy complications such as preterm birth, low birth weight, and the risk of bleeding (Demilew, Alene, and Belachew, 2020). The situation is even worse when a significant number of pregnant women that are iron-deficient are not aware of it, since fatigue and dizziness, which are symptoms of iron deficiency, are usually treated as normal discomforts of pregnancy. Checking hemoglobin levels regularly is a vital activity; however, it is often ignored because of different obstacles, such as the lack of healthcare facilities and low awareness about the importance of early diagnosis (Wakwoya, Belachew and Girma, 2023).

Table 1. Study Result on the Effect of Nutrition Education

Author (Year)	Country	Study Design	Sample (I/C)	Participants	Type of Nutrition Education	Delivery Mode	Duration	Main Intervention Description	Outcome Measure	Key Results
Rahman et al. (2022)	Malaysia	RCT	60/60	Pregnant women aged 18-35 years, 1st-2nd trimester, healthy	Structured digital nutrition education (MyPinkMom) focusing on anemia prevention	Mobile app (interactive videos, quizzes, meal tracking)	6 weeks	Six modules on dietary diversity, iron and vitamin C intake, and anemia prevention	Hb (g/dL), nutrition knowledge, dietary intake	Mean Hb increased from 10.95±1.05 to 12.03±1.18 g/dL in intervention (p<0.001); improved knowledge and iron-rich food intake
Beressa et al. (2024)	Ethiopia	Cluster RCT	224/223	20-40 years, 2nd trimester, healthy	Group-based education emphasizing iron-rich diets and IFA adherence	Face-to-face group sessions during ANC	9 months	Six midwife-led sessions using Health Belief Model (HBM)	Hb (g/dL)	Significant Hb improvement in intervention vs control ($\Delta=0.12\pm0.04$ g/dL, p=0.002)
Wakwoya et al. (2023)	Ethiopia	RCT	183/183	20-35 years, early pregnancy, no complications	Combined face-to-face counselling and mobile text reminders	Hybrid (clinic+SMS)	12 months	Behavioral-based nutrition counselling and reminder messages promoting dietary compliance	Hb (g/dL)	Intervention group had significantly higher Hb ($\beta=0.50$, p<0.01)
Elsharkawy et al. (2022)	Egypt	RCT	98/98	20-40 years, 2nd trimester, mild anemia (Hb 8-11 g/dL)	Multimedia-based education on anemia prevention and diet	PowerPoint sessions, booklets, WhatsApp group	3 months	Four structured sessions integrating audiovisual and print media	Hb (g/dL), nutritional knowledge, IFA adherence	Hb increased from 10.9±1.01 to 11.75±0.93 g/dL (d=0.85, p<0.001); improved supplement adherence
Sunuwar et al. (2019)	Nepal	Quasi-experimental	54/53	18-35 years, 2nd trimester, mild anemia	Individual counseling on diet diversity using local food sources	One-on-one counselling	3 months	Personalized sessions with dietary planning and follow-up	Hb (g/dL), nutrition knowledge, iron-rich food consumption	Hb rose from 11.49±0.82 to 12.05±0.40 g/dL (p=0.002); significant knowledge gain (p<0.001)
Nahrish et al. (2020)	Indonesia	Quasi-experimental	70/70	20-40 years, 2nd trimester, anemic (Hb 8-11 g/dL)	Home-visit visual nutrition education using pictorial flipcharts	Home visits	2 months	Two midwife-led home visits on anemia prevention and dietary practices	Hb (g/dL), hematocrit	Hb increased significantly in intervention group (p<0.001); higher hematocrit improvement (p<0.001)
Anato & Reshid (2025)	Ethiopia	Quasi-experimental	99/99	18-40 years, 2nd trimester, healthy	Group and individual sessions on dietary diversity and IFA compliance (HBM-guided)	Community-based sessions	4 months	HBM based education delivered by health extension workers	Hb (g/dL), anemia prevalence, IFA adherence	Anemia prevalence reduced 27.8%→7.2%; improved IFA compliance (OR=2.26, 95% CI 1.55-3.29, p<0.001)

According to Table 1, this review incorporates seven studies that consistently delivered nutrition education interventions to pregnant women aged 20–40 years, primarily during the early to mid stages of pregnancy (first and second trimesters). In their quasi-experimental study “Effect of Nutrition Education and Iron-Folic Acid Supplementation on Anemia among Pregnant Women in Ethiopia,” evaluated an HBM-guided nutrition education intervention combined with Iron-Folic Acid Supplementation (IFAS), demonstrating its role in improving hemoglobin concentrations and promoting adherence to IFAS among pregnant women (Anato & Reshid, 2025). This study focused on 198 pregnant women categorized into two cohorts: an intervention cohort that participated in IFAS as well as in-depth nutritional counseling, while the other was a control cohort that only received an outline of the counseling. Several statistical analyses, such as t-tests, ANOVA, and multiple regression, were performed. The findings were that the assimilation of anemia and IFAS in the intervention cohort significantly improved. At the beginning of the study, the proportion of participants with adequate understanding was very low; slightly more than 50 percent in both groups. After the intervention, the proportion of participants with a good understanding of nutritional principles was 84.5% in the intervention cohort, while in the control cohort it was 62.9% and this was statistically significant ($p < 0.001$). Regarding hemoglobin changes, the intervention and control groups were 11.78 ± 1.33 g/dL and 12.65 ± 1.26 g/dL, respectively ($p < 0.001$). This result was significant; g/dL increased by 0.8 g/dL. Participants adhered to the diet, and the intervention cohort increased from 33.8% to 79.4%, while the control cohort only increased from 32.4% to 40.6%. The difference was substantial ($p < 0.001$), strongly supporting the effectiveness of HBM-based nutrition counseling on adherence.

Another factor that influences the results is the educational level of the participants. According to research, responsible women who attend secondary schools or universities are about four times more likely to consume additional IFA food types than women who have not received formal education (Digssie Gebremariam et al., 2019). Several analyses suggest that when complex variables are adjusted for, the likelihood of consuming more IFA at the end of the study is 2.7 times higher compared to the baseline. Overall, this research indicates that nutritional studies based on the Health Belief Model (HBM) and the supplementation of IFA not only enhance knowledge but also increase hemoglobin levels and the consumption of adaptive resources. These results provide strong support for integrating knowledge-based interventions in the continuum of routine maternity and postnatal care, which enhances their

potential to alleviate the journey of anemia in pregnant women (Niguse and Murugan, 2018). It is suggested that further research be conducted to test other scientific methods that may be more effective in promoting dietary and health-related behavioral changes.

The title of their research, “The Impact of Nutritional Education on Hemoglobin Levels of Pregnant Women in South-East Ethiopia,” is a community-based study conducted through a cluster-randomized controlled trial involving 447 pregnant women, demonstrating that theory-based nutritional education effectively improves pregnancy outcomes (Beressa, Whiting, and Belachew, 2025). Between February and December 2021, the study assigned 224 women to the intervention group, where six intensive nutritional education courses were conducted based on health models and the theory of planned behavior. In contrast, 223 women received standard prenatal care as the control group. Results show a positive effect of the educational intervention on increasing hemoglobin levels. For the ‘teachable moment’ group, there was a drop in hemoglobin by 0.36 g/dL, while in the control group, there was a drop of 0.12 ± 0.04 g/dL. The other result identified that intake of coffee and tea significantly reduced hemoglobin levels: each additional cup of either beverage lowered hemoglobin levels by 0.14 g/dL. Regardless of the level of impact dietary modifications may have, this research highlights concern towards restrictive measures regarding the consumption of specific beverages intended for use with iron supplementation therapy in pregnant women. Changes at the community level targeting behaviours aimed at raising haemoglobin levels are deemed valuable in addressing the high prevalence of anaemia in low-resource settings.

Providing a quick overview of the importance of family awareness significantly increases knowledge about diet during pregnancy (Nadia B Elsharkawy et al., 2022). A high p-value of 0.05 indicates that any differences may be due to random factors. It has been shown that subjects in the experimental group had significantly better hemoglobin levels than those in the control group. The null hypothesis is rejected because the p-value is significantly less than 0.05, indicating that the difference is statistically significant. The control group, who used the program during the first month of the study, was very active, and this had a positive effect on increasing the subjects hemoglobin levels. The ratio of folate to iron was significantly higher in the intervention group at 82.31 ± 8.71 compared to the control group, which had significantly higher results at 66.78 ± 13.82 ($p = 0.001 < 0$). The cognitive levels were not different between the two groups: $p = 0.070$, nutrition: $p = 0.410$, and hemoglobin levels: $p = 0.584$, as shown by preliminary analysis. This confirms the finding that indeed, the observed

changes were due to the intervention. In addition to face-to-face meetings, informational resources and support on WhatsApp have led to significant progress in knowledge and practical skills, and related clinical outcomes. These results demonstrate the need for a broad and systematic, evidence-based approach to maternal-infant education, such as in the case of anaemia in pregnancy. The report on the approach indicates that useful and successful elements include the WhatsApp platform (for continuing education), interactive PowerPoint presentations, educational level, and regular attendance at Antenatal Care (ANC) appointments. Furthermore, in relation to the educational sessions, all aspects of the programme are focused on providing effective methods of delivery and ensuring consistent participation over the ensuing years. As previously identified, this program was effective in increasing hemoglobin and iron levels, improving nutritional knowledge, and facilitating iron supplementation among anemic pregnant women. Therefore, it can be proposed to scale up the program and help integrate it into standard prenatal care in challenging settings.

In their quasi-experimental study, "Effects of Picture-Guided Education and Counseling on Improving Knowledge of Anemia, Nutrition, and Adherence to Iron Therapy in Anemic Pregnant Women in Indonesia," (Nahrisah et al., 2020) measured the effectiveness of a health literacy model-based intervention for anemic pregnant women. 140 subjects were randomly divided into two groups, one of which was the intervention group that received two home visits combined with picture-guided teaching and counseling, while the other group was the control group that received routine prenatal care. The results showed a striking difference between the groups, and in the preventive treatment group, significant differences were also reported for hypertension ($F=122$, $p<0.001$) and for cholesterol ($F=373$, $p<0.001$). Improvements in metabolic parameters, along with a diet rich in moderately light ingredients, iron, and ferric acid supplements (all $p<0.001$) were maintained.

This focused intervention illustrated birth rate increases by more than the expected due rate while improving nutrition at a statistically significant rate for both ($p<0.05$). Iron-rich food intake and a supportive feeding regimen were the most important factors in the positive changes in hemoglobin and hematocrit. This study indicates that imaging and direct conversation may be effective modalities for anemia management during pregnancy, particularly in areas with a high burden of chronic health conditions. These findings support several intervention components that could be incorporated into cost-effective maternity care options. This healthcare based approach has improved medical indicators without causing significant changes in knowledge and behavior. The participants domain of

knowledge has leveled high, showing a deeper understanding of the risks and preventive measures against anemia. This success is also proved by the training on how to handle supplements side effects, for example, consuming the supplements with food to reduce nausea.

In their randomized trial titled 'The Effect of Theory on Intervention Programs for Pregnant Women with Anemia, they tested the MyPinkMom program, which is a theory-driven intervention provided through mobile resources, and confirmed its effects on improving health outcomes related to anemia among pregnant women (Abd Rahman et al., 2022). The intervention group that could access six infographic video materials via a mobile application recorded better results than the control group that was only given routine advice, according to a randomized controlled trial performed at two prenatal clinics. It can be inferred from the data that the intervention group showed an increase in hemoglobin levels until the sixth week (large effect, partial eta-squared=0.268), an increase in the knowledge of anemia (very large effect, $\eta^2=0.622$), and an increase in the consumption of iron and vitamin C from their diet ($p<0.001$). In addition, a decrease in tannin intake was observed ($p<0.001$), which inhibited copper removal. The long-term change in blood pressure was much greater in the intervention group than the control group, with a p-value of less than 0.001. The improvements, occurring rather quickly, were seen in the intervention group at week 12, whereas changes did not occur in the control group. Improving knowledge, attitudes, and behaviours as it pertains to nutrition, which, in turn, increases haemoglobin and prevents anaemia, is the goal of the mobile chat application 'My Pink Mum'. To summarise, the results reinforce the integration of digital mechanisms with conventional teaching practices in the interest of public health pertaining to mothers and children. The study's authors uncovered that treating asthma with mobile text messaging improved clinical results in asthmatic pregnant women.

In a quasi-experimental study, Sunuwar et al. (2019) assessed the impact of anemia on the health of 115 pregnant women and concluded that nutrition education combined with a specific (iron-rich) diet resulted in improvements in health outcomes. Another version of this portion of the study, using intensive in-person counseling supported by regular telephone counseling, with equivalent anemia, resulted in better health outcomes with anemia ($0.56\pm0.40\text{g/dL Hb}$) compared to controls without counseling ($0.16\pm0.82\text{g/dL Hb}$), giving a statistically significant difference of 0. significant ($p=0$). rutabaga. nutrition. Knowledge scores about anemia and iron deficiency in the intervention group were 8.26 relative to the control group (1.05) $p<0.001$, highlighting the large

difference in iron-rich diet intake with the control diet, $p < 0.05$). The intervention subgroup demonstrated clear benefits in pre-specified outcomes. The data emphasize that the nutritional/metabolic dysregulation intervention in children with anemia, combined with cognitive education, dietary prescriptions, and supplemental support modules with reproductive therapy, is within a feasible range. Reinforcing focused counseling with nutrition education encouraged participants to advocate for nutrition education and counseling among their peers, thus doubling the effect. After education, the average anemia knowledge score recorded among pregnant female participants increased to 17.37. Research shows that iron-rich foods, especially red meat, fish, liver, vitamin C-rich fruits, dairy products, eggs, and vegetables, are the best foods.

“Effects of Nutrition Education and Counseling for Pregnant Women in the Eastern Soa Region of Ethiopia” examined the effects of one year of nutrition education and counseling in southern Ethiopia (Wakwoya, Belachew and Girma, 2023). In the intervention group, women received three months of nutrition education based on the health belief model, supported by weekly text messages and iron-rich diet advice, while the control group received no formal education. Results indicated that the control group, namely the hemoglobin average, rose from 12.08 to 12.53 ($p = 0.01$). Hypertension prevalence was reduced from 14.7% to 9.2% and analysis indicated that the outcomes from the intervention group were different from the control group outcomes ($p < 0.01$). For this study, the participants were pregnant women, and those with chronic conditions were excluded. This indicates that education on maternal nutrition can be beneficial to the health of the mother. Such policies

should be integrated into the standard operating procedures. This review is not without its flaws. Significant heterogeneity was noted while reviewing the literature, probably reflecting differences in intervention duration, method of delivery of interventions, and participant characteristics. In addition, the lack of participant and/or personnel blinding in most studies introduces a high risk of recruitment bias. Moreover, the presence of quasi-experimental designs in some studies and different tools for the assessment of hemoglobin levels, cognitive function, and diet affects the outcomes of this review. Equally, this review fails to take into consideration the nutrition education components and narrows its scope to English and Indonesian, which could add to publication bias.

This approach reflects the emerging trends in nutrition education from traditional in-person consultations to digital technologies (SMS, video, and social media). Different intervention timing may also have contributed to the discrepancies in the study results. The results of the quality assessment of the trials are presented in Table 2. The effects of randomized sequence generation and allocation blinding were largely unsuccessful, indicating that the randomization and allocation methods were not sufficiently controlled. However, both the participants and the staff felt that there was a lack of competence, suggesting that the implementation of competency-based interventions in nutrition education was not feasible. Variability may also be due to a lack of data collection and selection bias between studies, and the use of selective reporting and other assessment methods between studies. Overall, methodological quality was acceptable, and improvements in hemoglobin levels and nutritional status were reported, although interpretation remains unclear.

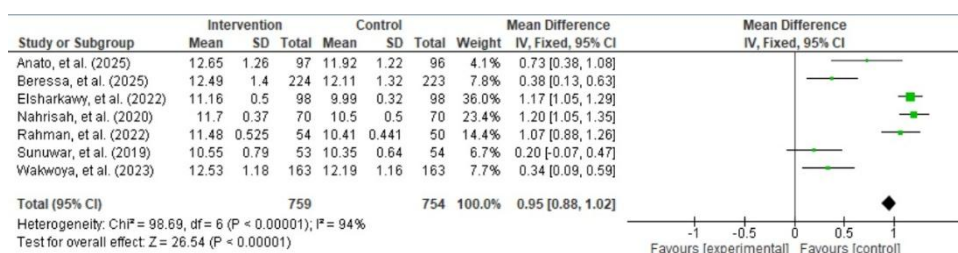


Figure 2. Forest plot of meta-analysis (Hb improvement)

A graphical representation of the information obtained from all seven trials shows an effect on hemoglobin levels of 0.73 g/dl ($p < 0.00001$). However, the studies varied significantly ($I^2 = 94\%$), possibly due to heterogeneity in study type, study framework, or population parameters. The high heterogeneity indicates that although all interventions were beneficial and

effective in increasing mean hemoglobin levels, the degree of variation in the mean for each intervention was quite large. It can be assumed from the above information that hemoglobin levels in rats can be increased by the application of exercise training, although the effects of the training or the training itself may be inconsistent.

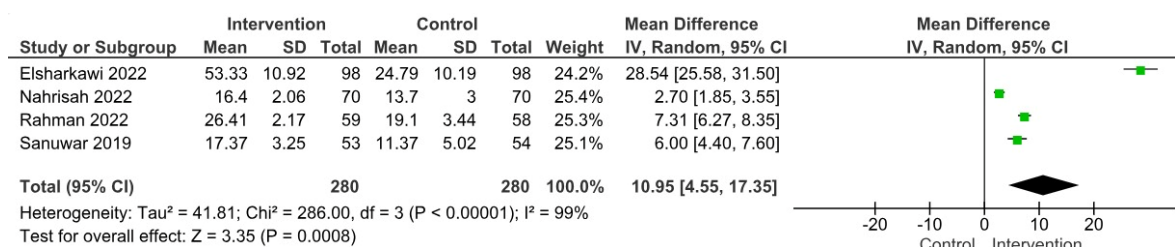


Figure 3. Forest plot of meta-analysis (knowledge)

This graph summarizes the results of four separate studies evaluating the effect of nutrition education on the dietary behaviors of pregnant women. Coordinated measures indicated statistically significant risk factors (p -value=10.95 [95% CI: 4.55–17.35] and p -value=0.0008), primarily related to time to diagnosis and time to prognosis. In each study, there was an increase in dietary intake following nutrition education. Studies that incorporated different teaching styles, supplemental visual media, and digital support were more flexible. Significant improvements were also seen in dietary intake from nutrient-rich diets and more balanced dietary patterns from interventions that included guidelines along with low-fat foods. As noted in the analysis of the graph, the studies were centred only on the outcomes, using numerous targets with very

narrow parameters ($I^2=99\%$). The data suggest that there is considerable discrepancy in the timing of the various studies in relation to the design of the studies, considering the populations as well as the interventions involved. The studies in question have similar favourable outcomes, which demonstrate that nutrition education is an important component in improving dietary intake in all women. Overall, the evidence substantiates that nutrition education during pregnancy is an important means of increasing awareness concerning balanced diets, together with associated dietary practices. Structured, interactive, and culturally sensitive education among women has been shown to have a strong impact on mothers dietary practices, facilitating appropriate dietary guidance and physical activity during pregnancy.

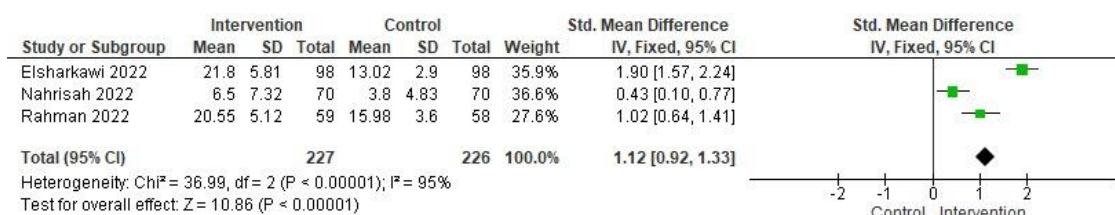


Figure 4. Meta-analysis forest plot (Dietary Intake)

The difference between the three studies was statistically significant with an odds ratio of 1.12 (95% CI: 0.92–1.33) and $p < 0.00001$. Comparability of the studies was determined by heterogeneity ($I^2=95\%$); however, high heterogeneity existed. Differences in dietary habits, gender, population and program duration, and household characteristics may help explain these differences. The findings, which provide evidence supporting appropriate nutrition education during pregnancy, as well as differences in outcome measures likely a result of program demographics and reproductive status, indicate that effect sizes are highly subjective. The difference was significant with $p < 0.00001$ and $Z=10.86$, but the main message of this study remains that the intervention effect persists over time. These findings raise the need to offer daily nutrition counseling. There is a gap in the literature addressing the importance of nutrition and dietary intake during pregnancy.

In this regard, a systematic review and subsequent meta-analysis demonstrated clear

support for nutrition counseling as an intervention for healthcare providers. Of the interventions examined, seven contributed to increased hemoglobin levels among pregnant women. A multi-faceted approach, combining face-to-face training with printed materials, books, videos, mobile apps, and text messaging, tended to produce the best results. Most strategies enhanced knowledge and adherence to iron and folic acid dietary supplements, as well as overall dietary practices. The meta-analysis indicated that there was a general positive effect on hemoglobin, knowledge, and nutrition, even though the studies were not equalized owing to the imbalance in the studies. Although some may question the meta-analysis approach, one has to recognize that most trials reported good methodological quality, with the associated minimal selection bias.

Despite the progress attested in the previous sections, every work leaves “puzzle pieces” that need to fit in holes left therein, and this study is no different in that regard. The absence of limbs is

worse in this case, where the limbs in question are the 90 percent I2 values that attest to the random population of different clinical study types in this synthesis. The high degree of heterogeneity implies that the interventions are heterogeneous, reflecting variations in contextual and methodological factors within and/or between studies. This is most likely to happen because of differences in intervention timing, prior exposure levels of the intervention, sample characteristics, and tools employed to measure hemoglobin concentration, nutrition knowledge, and general eating behavior.

Because of their size, the gaps identified more significant differences that need more fine-grained analyses at the subset level. These analyses took a more macro approach, controlling for session length, the type of interventions, and the component theories. For instance, in multimodal or theory-based interventions in which face-to-face counselling is supplemented with visuals and digital tools, there is still greater educational content compared to programmes geared towards education only. Programmes administered in the first trimester may also work because dietary practices and subsequent compliance can be established earlier in life. It also seems that maternal age is a modifier of response since younger pregnant women tend to be more receptive and open to behavioral changes, whereas success may be lower for older women or those with more than one child due to ingrained habits or previous pregnancy experiences. Performing subgroup analyses of this nature will afford a better understanding of the most effective intervention groups and models, and can help explain reasons for the high variability observed in this meta-analysis.

Along with heterogeneity, most studies involve uncertainty, which may be due to a lack of agreement among peers and research leaders. The inclusion of other empirical research may have damaged the internal validity of the collective findings and the overarching conclusions drawn from the research. Behavioral and physiological effects cannot be reliably estimated without considering long-term impacts. Finally, there is a reliance on courses conducted in English and Indonesian, limiting the potential range of research studies in other languages.

CONCLUSION

Nutritional guidance during pregnancy alleviated anaemia and increased haemoglobin levels. The most effective method utilised a multiprofessional approach which involved personal counselling enhanced with audiobook and video resources and reinforced with SMS follow-ups. These programs also enhanced the health literacy of participants regarding appropriate dietary practices, adherence to iron-rich foods and supplements, and adherence. Thus, these studies underscore the

importance of research-based, comprehensive, and integrated nutritional counseling in prenatal care, as such programs are highly effective in reducing blood pressure among pregnant women.

Acknowledgement

The authors would like to express their sincere appreciation to all researchers whose original work formed the foundation of this systematic review and meta-analysis. Their valuable contributions to the field of maternal nutrition and public health are deeply acknowledged. We are also grateful to the faculty members, academic staff, and peers from the Master of Public Health Program at Universitas Airlangga for their ongoing encouragement, insightful discussions, and constructive feedback throughout the research process. Special thanks are extended to those who provided critical reviews and thoughtful suggestions that significantly enhanced the quality and clarity of this manuscript.

Conflict of Interest dan Funding Disclosure

The authors declare no conflict of interest related to this publication. This study was conducted independently and did not receive any funding or financial support from governmental, commercial, or non-profit organizations. All aspects of the research, including design, data collection, analysis, and manuscript preparation, were carried out without external influence or sponsorship.

Author Contributions

MZQ: format analysis, methodology, project administration, software, visualization, writing-original draft, data curation. AYF: conceptualization, resources, writing-review & editing, and validation. TM: supervision.

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