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Effectiveness of Nutrition Education on Knowledge of Anemia and Hemoglobin Level in Female Adolescents Aged 12-19 Years: a Systematic Reviews and Meta-Analysis

Efektivitas Edukasi Gizi Pada Pengetahuan Terkait Anemia dan Kadar Hemoglobin Remaja Putri Usia 12-19 Tahun: Tinjauan Sistematis dan Meta Analisis

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ABSTRACT

Background: Anemia is a common health problem among adolescents that needs to be resolved immediately. It is estimated that more than 50% of female adolescents aged 12-15 years have anemia. Some of the anemia's effects on adolescents include stunted growth, decreased learning ability, and susceptibility to infectious diseases.
Objectives: To identify evidence for nutrition education's effectiveness on anemia knowledge and hemoglobin levels in female adolescents aged 12 to 19.
Methods: Using study eligibility criteria, three electronic databases (Scopus, Science Direct, and Pubmed) were searched within five years for relevant articles. Review Manager (RevMan) version 5.4.1 was used to analyze the research findings.
Results: Based on the results, there was no significant relationship between education and anemia knowledge in the control and treatment groups ($p<0.05$). Neither group also had a significant relationship between nutrition education and Hb concentration. However, the Active, Creative, Effective, and Fun Learning or *Pembelajaran Aktif, Kreatif, Efektif, dan Menyenangkan* (PAKEM) program approach impacted adolescent anemia knowledge. The mean difference value of 0, which indicates the intervention group is more effective than the control group, presented significant results. The estimated effect can be seen in the forest plot image to the left of the vertical line.
Conclusions: Based on the meta-analysis, the PAKEM method is a nutritional education method that provides significant results on female adolescents' knowledge regarding anemia and Fe tablet consumption. However, the nutritional education method did not affect hemoglobin levels.

INTRODUCTION

The World Health Organization (WHO) defines adolescents as people between 10 and 19[1]. Anemia is a severe public health issue that impacts adolescents' life cycles, especially among female adolescents. Anemic adolescents are limited in their growth, learning capacity, and ability to focus on daily tasks. Anemia also affects their susceptibility to infection, the likelihood of dropping out of school, level of physical fitness, and output at work[2]. Low hemoglobin (Hb) or red blood cell levels (RBCs) are the two components of anemia. Anemia caused by a lack of iron is most frequently seen. Based on hemoglobin levels, anemia can be classified as non-anemic (≥12 g/dL), mild (11.0-11.9 g/dL), moderate (8.0-10.9 g/dL), and severe (<8 g/dL). These hemoglobin level cutoff values apply to non-pregnant women, including women of childbearing age and female adolescents[3].

Due to its significance as a period of growth and development, adolescence is an ideal time for therapies to alleviate the risk of anemia. Missing nutrition instruction and iron supplementation could exacerbate the cycle of anemia and iron deficiency. Along with satisfying their growth requirements, female adolescents must consume enough iron before pregnancy[4]. Because it cannot generate iron on its own, the human body needs iron as one of the essential minerals. Since iron is essential to health, it has been referred to as the body's gold. The majority of the iron in the body is contained in hemoglobin-like protein, which red blood cells contain. The oxygen in the blood is carried by hemoglobin into the lungs and all of the body's tissues[5]. Due to lower iron reserves in general, women are more susceptible to anemia than men, and the advent of menstruation increases the need for iron to make up for menstrual

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blood loss. Young women, including female adolescents, are more at risk of developing certain diseases because they consume less overall food or energy and have higher menstrual losses. An iron deficit6 brings on anemia.

According to studies, adolescents' risk of anemia tends to rise with age and coincides with adolescence when growth is most accelerated. Between the ages of 12 and 15, when requirements are at their highest, there is the most considerable anemia incidence. It has been claimed that more than 50% of females in this age group are anemic[7]. The 12-to-19-year age range was selected for this meta-analysis because it corresponds to the minimum age range in seven journals included in the study selection process. This age range also fits the upper age limit for adolescents as defined by the WHO.

According to one definition of nutrition education, it is the process of persuading individuals to behave independently to achieve good nutritional status. Nutrition education is the most popular tactic for boosting community nutrition[8]. Nutrition education has the ultimate goal of increasing nutritional status. To meet this goal, nutrition education plays a crucial role in community nutrition by enriching nutritional and health-related knowledge, including anemia[9].

In addition, a lack of protein, iron, and other micronutrients in adolescent females causes anemia. This is made worse by ignorance about nutritional knowledge that may impact their behavior[10]. A few factors favor nutritional education, including affordability, viability, lack of adverse effects, and sustainability through knowledge growth that may affect dietary behavior. Thus, adolescents' knowledge is essential in ensuring the effectiveness of anemia reduction[9]. A meta-analysis was conducted to determine which methods effectively deliver nutrition education to increase female adolescents' anemia knowledge and hemoglobin levels. Providing nutrition education through specific methods is hoped to affect female adolescents' knowledge and hemoglobin levels.

METHODS

The randomized and quasi-randomized controlled studies included female adolescents aged 12 and 19 who received nutrition education. Nutrition education was delivered to participants through videos, pamphlets, group discussions, etc. Studies that included methods of nutrition education had an intervention and control as the group design and had outcomes for Hb values and anemia knowledge among adolescents were included in this study. Studies recruiting from all demographic and geographic settings were eligible. Studies involving pregnant people, babies, or people with illnesses that significantly modify human iron metabolism and studies conducted on animals were not included. Hemoglobin concentration and knowledge of anemia were the primary outcomes. A meta-analysis was conducted for outcomes reported by more than one eligible trial.

Three computerized bibliographic databases were searched with the following results: Scopus yielded 111 articles, Science Direct yielded 100 articles, and Pubmed yielded 128 articles to be screened. Language restrictions were set to only English. The search strategy used for the databases was a combination of "Nutrition education" and "Iron" or "Fe," "Supplementation," and "Adolescents." Searches were done from September to October 2022. Seven studies met the criteria for inclusion, as described in Figure 1. Studies identified by this search strategy were stored in Covidence software. Studies with titles and abstracts that made their ineligibility clear were eliminated. In all cases where full access was unavailable, full-text papers were assessed for eligibility before extracting data from available data.

A random effects meta-analysis was used to synthesize predefined outcomes reported by the seven studies. The standardized mean difference (SMD) was produced for data using different scales, whereas the mean difference (MD) was derived for continuous data taken on the same scale. Only end-point data from several studies were presented, and standard deviations (SDs) for change from baseline were frequently lacking. Thus, end-point data rather than change from baseline data were used in the meta-analysis. A results meta-analysis was conducted using Review Manager (RevMan) version 5.4.1. Since the data were given as continuous data, it needed information on the number of participants, mean, and standard deviation of two groups (the intervention and the control groups), among other things.

RESULTS AND DISCUSSION

The article database search results allowed 339 articles to be identified in total. After removing duplicate articles, 285 articles were screened for titles and abstracts. Eligibility criteria were used to assess 12 full-text articles. Five articles were excluded as they had the wrong intervention, study design, and patient population. In the end, there were seven studies included that contributed to the meta-analysis. Tables 1 and 2 below identify the study characteristics from selected articles as data sources for the meta-analysis. The seven studies were divided into two categories. The first category included articles discussing nutrition education related to anemia knowledge (n = 4). The second category included articles discussing nutrition education concerning hemoglobin levels (n=3).

Based on Figure 2, nutrition education related to anemia differences resulted in a mean knowledge of 4.92 between the intervention and control groups (four studies; 454 subjects; 95% confidence interval [CI] = -0.90-10.73; p<0.00001; I2 = 99%). When viewed from heterogeneity, all journals had high heterogeneity because of the p-value of less than 0.05 (0.00001) and I2 more significant than 50% (99%). Nutrition education did not significantly increase knowledge in research results (p = 0.10).

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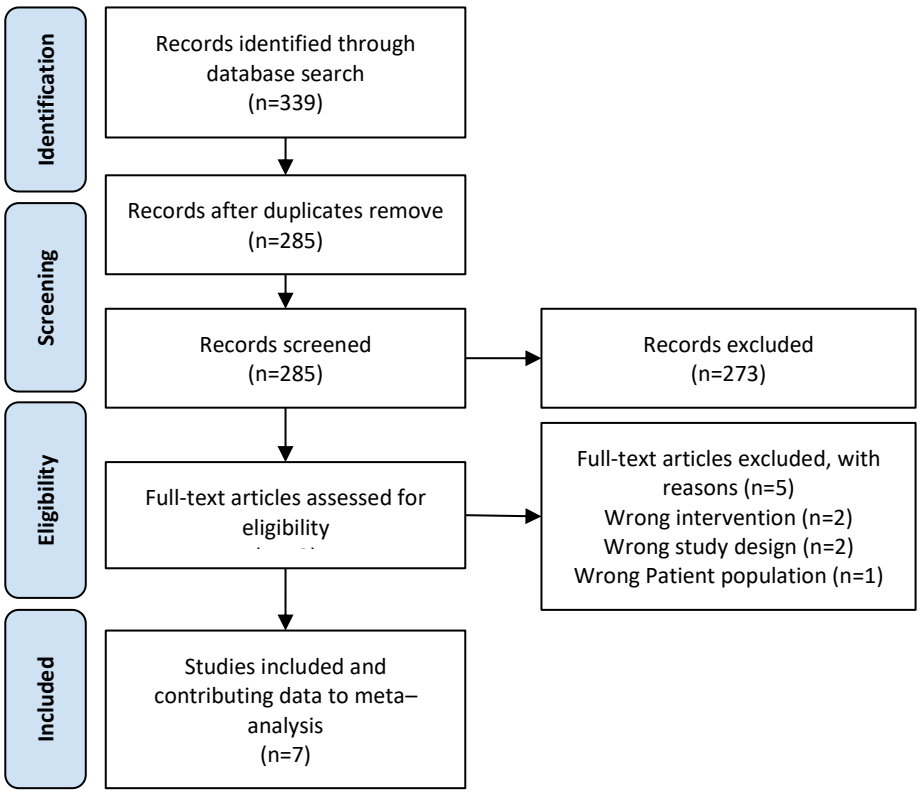

Figure 1. Diagram of the study selection process using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

Figure 2 shows four studies, three of which did not find significant relationships between nutrition education and anemia knowledge. Singh delivered nutrition education in 2020 using slide shows, pamphlets, visual displays, and weekly iron-folic acid supplementation (WIFS). Gambir delivered nutrition education using nutrition diary books and iron tablets in 2020. Madestria delivered nutrition education using videos and modified iron tablet packaging in 2021. None of these methods had a significant result on anemia knowledge of anemia among female adolescents.

From the four analyzed studies, only the study by Rusdin in 2021 found a significant effect on increasing knowledge regarding anemia among respondents. The nutrition education model was delivered as *Pembelajaran Aktif, Kreatif, Efektif, dan Menyenangkan* (PAKEM), or Active, Creative, Effective, and Fun Learning. It was considered more influential than nutrition education in the form of leaflets only.

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Table 1. Study characteristics for nutrition education related to knowledge of anemia

No	Author	Year	Country	Study Design	Participant Age	Study Characteristics
1	Rusdin et al.[11]	2021	Indonesia	A quasi-experimental with the randomized pretest-posttest control group design	249 female adolescents aged 12-18 years	• The research locations were the senior high schools SMAN 12 Makassar and SMAN 1 Makassar. Simple random sampling was used as the sampling method. SMAN 12 Makassar was chosen as the intervention group, and SMAN 1 Makassar was chosen as the control group. • Nutrition education was implemented using the PAKEM* program approach in the intervention group (n=35), while no intervention was given in the control group (n=35). • Nutrition education was given for two months, with the outcome defined as knowledge of anemia among female adolescents. The study yielded the mean ± SD for the intervention group (26 ± 2.45) and control group (28 ± 2.69).
2	Madestria et al.[12]	2021	Indonesia	A quasi-experimental design with a pretest-posttest control group design	124 female adolescents aged 12-15 years	• SMPN 2 Parigi served as the intervention group, and SMPN 1 Parigi was the control group. Stratified random sampling was used as the sampling technique. • Nutrition education was implemented using videos and modified iron tablet packaging (n=62), while only videos were given to the control group (n=62). • Nutrition education was conducted for three months with the outcome of anemia knowledge among female adolescents. The study yielded the mean ± SD for the intervention group (45.8 ± 4.43) and control group (36.43 ± 0.74).
3	Gambir et al.[13]	2020	Indonesia	A quasi-experimental study (non-randomized group pretest-posttest)	50 female adolescents aged 14-16 years	• The study's participants were 50 students from Indonesia's State High School 5 in Pontianak. Purposive sampling was used. • Participants were aged 14 to 16 years, had begun menstruation, and were willing to participate in research. Two groups were created from the sample: the intervention group (n=25) and the control group (n=25). • The intervention was given through nutrition education through nutrition diary books and iron tablets containing 60 mg of elemental Fe and 20 mg of folic acid for two months. For the control group, only elucidation and iron tablets were given. • The mean ± SD results for anemia knowledge in the intervention and control groups were 10.56 ± 9.08 and 8.55 ± 1.75, respectively.
4	Singh et al.[14]	2020	India	A quasi-experimental design with a pretest-posttest control group design	210 female adolescents aged 16-19 years	• Two senior secondary government schools in Delhi underwent an intervention. The study involved 210 female teenage school adolescents from two different schools. There were 106 teenage female adolescents in the intervention group's sample and 104 in the control group. • Six months of nutrition education were given using PowerPoint presentations, brochures, visual displays, and weekly iron-folic acid supplements (WIFS) for the intervention group. Only WIFS* were given to the control group. The iron-folic acid supplement included 100 mg of elemental iron and 0.5 mg of folic acid. • Anemia knowledge results were presented as mean ± SD. The intervention and control group results were 39.1 ± 1.1 and 29.1 ± 1.5, respectively.

*PAKEM (*Pembelajaran Aktif, Kreatif, Efektif, dan Menyenangkan*)
*WIFS (Weekly Iron-Folic acid Supplements)

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Table 2. Study characteristics for nutrition education related to hemoglobin levels

No	Author	Year	Country	Study Design	Participant Age	Study Characteristics
1	Kulkarni et al.[15]	2022	India	Randomized controlled trial	34 female adolescents aged 14-18 years	• The intervention group (n=17) and control group (n=17) were separated into the sample. • Interventions were given within three months to the intervention group through nutrition education through Intensified Health Education (IHE). No IHE was implemented for the control group. • The hemoglobin levels varied within the two groups. The intervention group had hemoglobin levels of 10.87 ± 1.66 g/dL, and the control group had hemoglobin levels of 9.79 ± 0.17 g/dL.
2	McCormack et al.[16]	2018	Pakistan	Randomized controlled trial	64 female adolescents aged 12-15 years	• The sample was divided into two groups: intervention (n=32) and control (n=32). • Interventions were given within two months to the intervention group through nutrition education through educational campaigns about anemia and iron-folic acid tablets. The control group only received education on iron-folic acid tablets. • The hemoglobin levels within the two groups were defined in g/dL. The intervention group had hemoglobin levels of 13 ± 1.5 g/dL, and the control group had 12 ± 1.8 g/dL.
3	Jalambo et al.[17]	2018	Malaysia	Randomized controlled trial	131 female adolescents aged 15-19 years	• The sample was divided into two groups: the intervention group (n=44) and the control group (n=42). • Interventions were given by nutrition education through lectures, posters, videos, booklets, and brochures for three months. No intervention was implemented in the control group. • The hemoglobin level within the two groups was defined in g/dL. The intervention group had hemoglobin levels of 12.04 ± 0.87 g/dL, and the control group had hemoglobin levels of 11.74 ± 0.84 g/dL.

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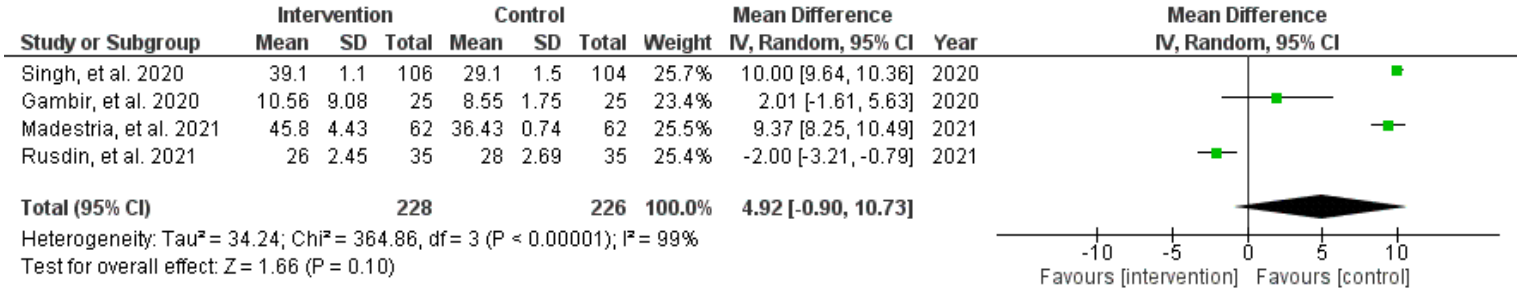

Figure 2. Forest plot for nutrition education related to knowledge of anemia

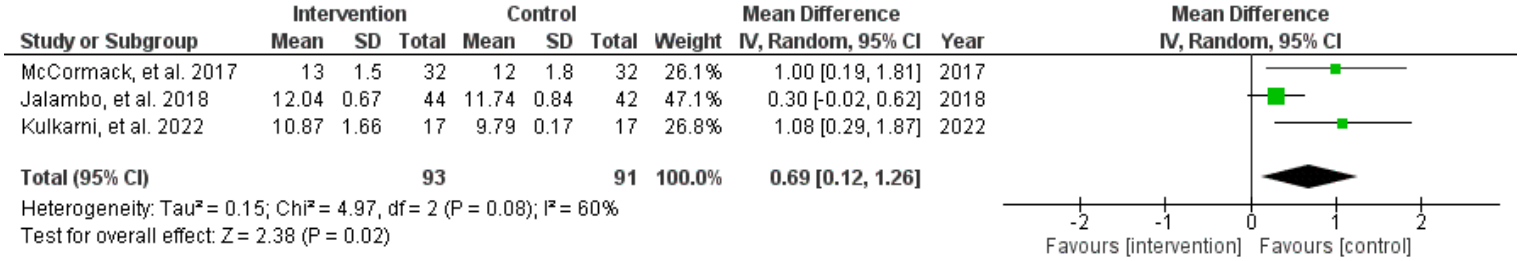

Figure 3. Forest plot for nutrition education related to hemoglobin levels

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Figure 3 shows that nutrition education resulted in a mean difference of 0.48 in Hb between the intervention and control groups (three studies; 184 subjects; 95% CI = 0.20-0.76; p=0.08; I2 = 60%). When viewed from the heterogeneity, all journals had high heterogeneity because of the p-value of less than 0.05 (0.00001) and I2 above 50% (100%). Nutrition education did not significantly increase hemoglobin levels based on the research results from the intervention groups that were given nutrition education.

Teaching an individual or a group about nutrition science is known as nutrition education. Health professionals play different roles in educating patients at a clinic, community, or long-term healthcare facility[18]. In these situations, the dietitian, nutritionist, or nurse helps people adopt new dietary habits and behavioral patterns[19].

The essential methods used to impart nutrition education are communication media and educational methods, which enhance the effectiveness of the nutrition education process. Nutrition education can be given through three methods according to the audience's needs, types of target groups, available resources, and feasibility[20]. The first is the particular method, where the nutrition educator communicates with the target individually. The particular methods used in nutrition education programs are personal contact or interviews, home visits, and personal letters[21].

In the group method, the nutrition educator communicates with people in groups, not individually. The group's size may be small (15 to 25 persons), medium (25 to 50 persons), or prominent (50 to 100 persons). The common group methods used in nutrition education are demonstrations, discussions, workshops, role plays or dramas, and field visits or tours[22]. Another method for nutrition education is the mass method. In the mass method, nutrition or health educators or agents work with communities of a large and diverse population without considering each person's or group's unique identity. The mass method is done when a large and widely dispersed audience is to be addressed or communicated quickly. Some mass methods use slides, radio, television, newspapers, leaflets, or posters[23].

From the meta-analysis using the Revman 5.4.1 version, it can be concluded that the PAKEM program approach is the most significant nutrition education approach for female adolescents. PAKEM is conditioned to active learning situations that are creative, effective, and fun. Nutrition education programs with the PAKEM approach have been known to increase knowledge of anemia among female adolescents. In the PAKEM approach, four elements build up nutritional education sessions[11].

The first is the participatory element, described as respondents' direct participation in receiving the information utilizing the lecture style as a quick introduction to anemia. This way, respondents can learn the fundamentals of the offered information. The second element, active engagement, is illustrated in group discussions. The environment is set up to encourage responders to ask questions, voice ideas, analyze and master the information presented, and come to practical conclusions that may be used in daily life[11].

The third element is creativity, demonstrated by the solution to anemia-related issues. The artistically presented material might inspire creative thinking by gathering knowledge or acting. The provision of modules and audiovisual materials connected to anemia is the fourth and final component, which is defined as effectivity. A supportive setting is necessary for effective learning. Participants, activities, topics, and instructional media must all be managed by the presenter[11].

Using flyers, leaflets, videos, and game applications, the PAKEM technique comprises lectures, group discussions, problem-solving, and game simulations (quizzes, role-play, and matching cards). PAKEM fosters intimacy between the researcher and the respondents, encouraging them to share their thoughts freely. According to one study, learning that involves visual, auditory, and kinesthetic components boosts learning efficacy by up to 90% as opposed to learning that is limited to seeing or hearing, which has an effectiveness range of 10% to 30%[24].

Jalambo conducted research in 2018, where education was given through lectures, discussions, posters, videos, booklets, and brochures. This method showed increased knowledge and attitudes toward anemia among female adolescents. When media and methods are combined, they will complement each other ($p<0.001$)[17]. On the other hand, research from Nikmah in 2022 found that nutrition education given only via leaflet significantly increased anemia knowledge ($p<0.001$) but not attitudes toward it ($p=0.198$)[25].

Several types of nutrition education aim to increase female adolescents' awareness and adherence regarding the importance of consuming iron tablets. Most people's hemoglobin levels return to normal after six months through oral iron supplementation. This is also related to each individual's obedience[26]. Providing nutrition education for 2-3 months is not able to provide significant results in increasing hemoglobin. This is because the increase in Hb levels is not enough from before the intervention was given. Iron absorption inhibitors should be considered[27]. Absorption may be delayed with coffee, tea, milk, and carbonated drinks. Multivitamins such as calcium, phosphorus, and magnesium interfere with iron absorption[28].

These findings have certain limitations, such as the short publication years for the selected articles. This may have resulted in some studies not being screened and included in the eligibility criteria. Studies gave little to no information on blinding to the intervention among the participants in the intervention and control groups. The age differences between participants may have affected their ability to understand the information provided by the researchers.

CONCLUSIONS

Nutrition education has been defined as persuading people to act in their best interest to obtain nutritional well-being. Nutrition education is the most widely used measure in the community for nutrition improvement. Nutrition education plays a vital role in community health and nutrition to enhance and enrich knowledge and correct faulty concepts about nutrition. The goal is to improve nutritional status. Based on the

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meta-analysis results, the PAKEM method was the nutritional education method with the most significant results on female adolescents' knowledge regarding anemia and Fe tablet consumption. The PAKEM program approach has built intimacy and interest among participants. However, the nutritional education methods analyzed did not affect hemoglobin levels.

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