



Review Article

Tackling Adolescent Anemia: A Systematic Review of Integrated Interventions

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Abstract

Background: Anemia in adolescent girls, particularly iron deficiency anemia, significantly affects health, including cognition, growth, and quality of life. The high prevalence of anemia in Indonesia underscores the importance of a comprehensive approach to increasing hemoglobin levels. **Objective:** To review the effectiveness of integrated strategies of diet, education, and supplementation in increasing hemoglobin levels in adolescent girls. **Methods:** The method used is a systematic literature review (SLR) with PICOS criteria (population, intervention, comparison, outcome, study design) to select relevant articles published in the last five years. Out of the 596 articles obtained, 28 relevant articles were selected. **Results:** The results show that integrated interventions are more effective in increasing hemoglobin levels compared to single approaches. The integration of diet, education, and supplementation resulted in significant improvements in iron status, nutritional understanding, and healthier eating habits. **Conclusions:** An integrated approach is a sustainable solution for addressing anemia in adolescent girls.

Keywords: Anemia, Adolescent girls, Hemoglobin, Integrated approach, Iron supplementation, Nutrition education.

معالجة فقر الدم لدى المراهقين: مراجعة منهجية للتدخلات المتكاملة

الخلاصة

الخلفية: يؤثر فقر الدم لدى الفتيات المراهقات، وخاصة فقر الدم الناتج عن نقص الحديد، بشكل كبير على الصحة، بما في ذلك الإدراك والنمو ونوعية الحياة. يؤكد الانتشار المرتفع لفقر الدم في إندونيسيا على أهمية اتباع نهج شامل لزيادة مستويات الهيموجلوبين. **الهدف:** استعراض فعالية الاستراتيجيات المتكاملة للنظام الغذائي والتعليم والتكملة في زيادة مستويات الهيموجلوبين لدى الفتيات المراهقات. **الطرائق:** الطريقة المستخدمة هي مراجعة منهجية للأدبيات (SLR) مع معايير PICOS (السكان، التدخل، المقارنة، النتيجة، تصميم الدراسة) لاختيار المقالات ذات الصلة المنشورة في السنوات الخمس الماضية. ومن بين المواد الـ 596 التي تم الحصول عليها، اختيرت 28 مادة ذات صلة. **النتائج:** تظهر النتائج أن التدخلات المتكاملة أكثر فعالية في زيادة مستويات الهيموجلوبين مقارنة بالأساليب الفردية. أدى دمج النظام الغذائي والتعليم والمكملات إلى تحسينات كبيرة في حالة الحديد والفهم الغذائي وعادات الأكل الصحية. **الاستنتاجات:** النهج المتكامل هو حل مستدام لمعالجة فقر الدم لدى المراهقات.

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INTRODUCTION

Hemoglobin has the main function of transporting oxygen throughout the body, particularly to organs and tissues [1]. Iron is the mineral that forms hemoglobin and is required by red blood cells [2]. Iron is essential for myoglobin synthesis, connective tissue, enzymes, collagen, and the immune system. Two billion people worldwide suffer from iron deficiency anemia, with 41.5% prevalence in developing countries. The main cause of anemia is low iron intake, especially in adolescent girls who require more iron due to menstruation and growth periods [3]. In developing countries, 40% of women suffer from anemia; however, representative data on micronutrient deficiency in Indonesia is still limited [4,5]. The impact of hemoglobin deficiency on the health of adolescent girls, particularly related to energy, cognitive development, and daily activities

[2]. Iron deficiency can lead to anemia and other health problems. Iron deficiency can lead to anemia and other health problems [6]. The source does not explicitly mention the link between hemoglobin and adolescent girls' cognitive development, but iron deficiency can lead to anemia, affecting their cognitive growth [7,8]. Anemia in adolescent girls can have long-term effects on skeletal and cardiovascular health, potentially leading to poor pregnancy outcomes [9]. Adolescent iron deficiency increases the risk of premature birth, low birth weight, neonatal infections, hypertension, and heart disease in offspring. [10]. Additionally, insufficient iron levels in adolescent girls can negatively impact their academic performance and overall cognitive abilities. Studies show that insufficient iron levels can disrupt concentration, memory, and problem-solving abilities, thereby impacting educational achievements and prospects [11]. Ensuring adequate iron intake

through a balanced diet and possible supplementation is very important for young women to prevent the adverse effects of anemia on their health and well-being. Raising awareness about iron-rich foods and improving health education programs is crucial for preventing and managing anemia [12]. Regular screenings and appropriate care for adolescent girls with anemia are crucial for reducing incidence and maintaining their health effectively. The challenges in increasing hemoglobin levels in adolescent girls include complex health issues due to risky behaviors such as smoking, alcohol consumption, and sexual behaviors that can affect the physical, mental, and social conditions of adolescents [13]. There are often limitations in access to iron-rich nutrition and a low level of nutritional knowledge and public awareness regarding the importance of adequate nutrition intake [14,15]. Measures such as providing iron and folic acid supplements, nutrition education emphasizing the importance of a balanced diet rich in iron, and improving access to healthcare services play a crucial role in preventing anemia in pregnant women [16,17]. Research shows that a comprehensive approach combining diet, education, and supplementation can effectively increase hemoglobin levels in adolescent girls, rather than relying solely on dietary changes or educational interventions [18]. Multidimensional intervention programs have effectively addressed stunting by integrating health, nutrition, and community education aspects, such as supplementary food, vaccination, and reproductive health education [19]. This integrated approach is crucial for comprehensively addressing adolescent health issues. This is the only way for adolescents to achieve optimal hemoglobin levels. Moreover, an integrated approach can also consider other factors that may affect adolescent health, such as social and psychological environments [20]. Therefore, an integrated approach is a more effective solution for comprehensively improving adolescent health. Previous research indicates limitations in integrating various intervention approaches into a single comprehensive analysis, where most studies focus solely on one approach without combining two or three main strategies: diet, education, and supplementation [21-23]. The lack of research on how to combine these three approaches affects hemoglobin levels in adolescent girls and highlights the need for more studies on the effectiveness of integrated methods. This research explores a novel approach to enhance adolescent hemoglobin levels through diet, education, and supplementation strategies, aiming to improve health policies and prevent anemia among teenage girls.

METHODS

This research uses the systematic literature review (SLR) method, which is a study that systematically identifies relevant journals and then summarizes the results of several studies to present comprehensive and balanced facts [24]. In SLR research, there are predetermined steps in the process of identifying journals, namely: formulating questions, searching for

articles relevant to the research topic, determining inclusion criteria for article selection, analyzing data, and reporting findings obtained from the reviewed articles [25]. The selection and screening of articles to be reviewed is a key step in systematic literature review (SLR) research. There are four criteria for selecting articles to be used in SLR research, namely access, completeness, novelty, and originality of the articles [25]. Meanwhile, in determining the inclusion criteria in SLR selection, the PICOS approach (Population, Intervention, Comparison, Outcome, Study design) is used. This research uses the systematic literature review (SLR) method, which is a study that systematically identifies relevant journals and then summarizes the results of several studies to present comprehensive and balanced facts [26-27]. In SLR research, there are predetermined steps in the process of identifying journals, namely: formulating questions, searching for articles relevant to the research topic, determining inclusion criteria for article selection, analyzing data, and reporting findings obtained from the reviewed articles [28-30]. The selection and screening of articles to be reviewed is a key step in systematic literature review (SLR) research, with four criteria for article selection to be used in SLR research: accessibility, completeness, novelty, and originality of the articles. Meanwhile, in determining the inclusion criteria in the SLR selection using the PICOS approach (population, intervention, comparison, outcome, study design) [31,32]: Population (P): Adolescent girls, focusing on teenagers who have problems with hemoglobin levels or are at risk of developing anemia. Intervention (I): An integrated approach to increasing hemoglobin may include dietary strategies (nutrition), health education, or educational interventions. Iron or relevant vitamin supplementation. Comparison (C): Compared to conventional approaches, such as the absence of intervention or only one type of intervention (for example, supplementation alone without education or diet). It can also be compared with a control group that does not receive any intervention. Outcome (O): Changes or increases in hemoglobin levels. Reduction in the prevalence of anemia or improvement in nutritional status related to hemoglobin, like an increase in iron or vitamins. Improvement in knowledge and behavior related to nutrition and health. Study Design (S): Controlled clinical trial, intervention study evaluating the effects of dietary approaches, education, and supplementation on hemoglobin levels in adolescent girls. In addition to the above criteria, the researchers added one inclusion criterion, namely that the articles used in this SLR research are studies published in the last 5 years (2019-2024). The articles used as data in this research were obtained from several sources, namely Google Scholar, PubMed, and Scopus. The search was conducted using keywords such as "increased hemoglobin or decreased anemia, adolescent girls, diet strategies, health education, and iron supplementation." These terms should be employed in diverse combinations to ensure comprehensive search. The findings of the article selection analysis employing the PRISMA methodology are as shown in Figure 1.

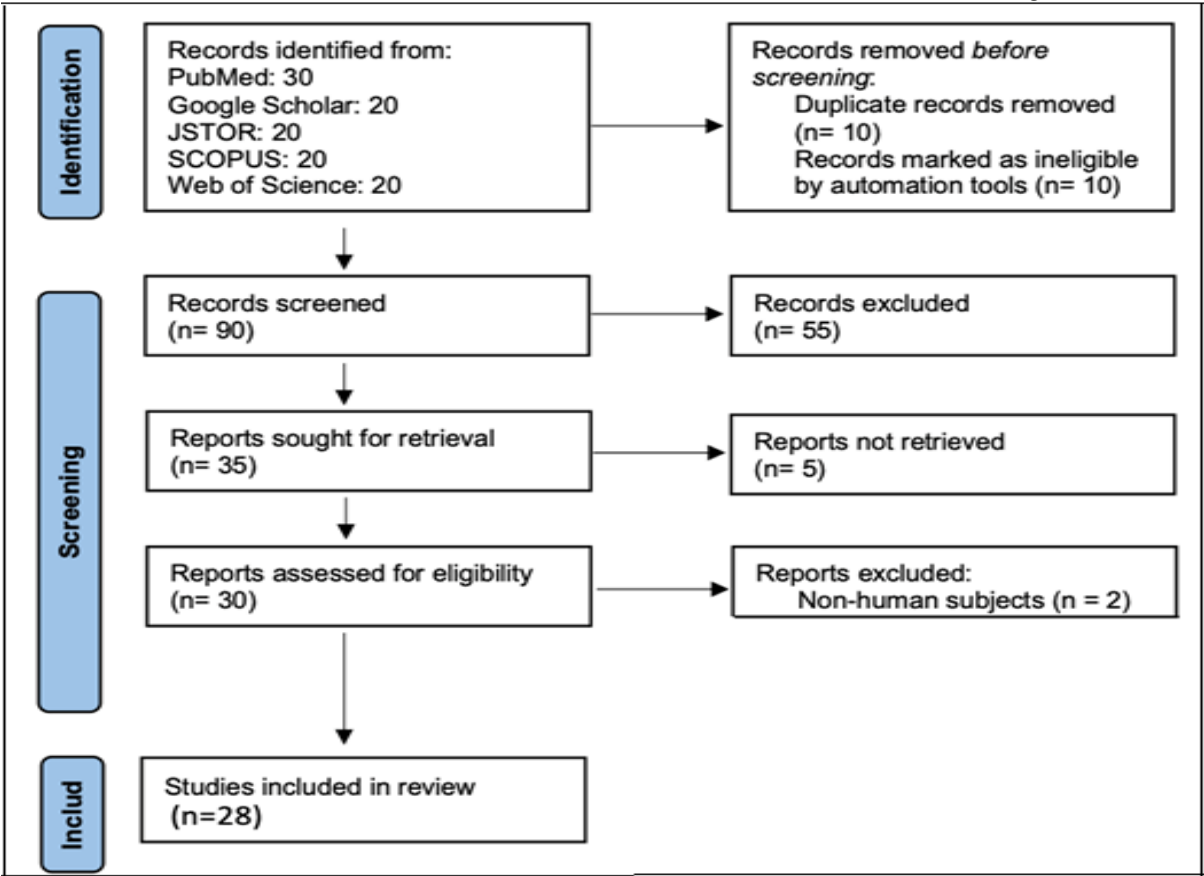


Figure 1: Prisma chart of the study

RESULTS

Based on the selection results, we found 110 articles related to hemoglobin improvement or anemia reduction, adolescent girls, diet strategies, health education, and iron supplementation. Next, the selection of articles published in the last 5 years, from 2019 to 2024, resulted in 90 articles. The research conducted article selection based on completeness, resulting in 30 articles that met the criteria using the PICOS approach. The remaining 28 articles were considered as shown in Table 1.

DISCUSSION

Often overlooked, iron deficiency anemia significantly impacts health, particularly among adolescents. Anemia is characterized by low hemoglobin levels in the blood, which affects the body's ability to transport oxygen to all tissues [60]. This can negatively impact cognitive function, growth, the immune system, and overall well-being [61-63]. WHO data shows that the prevalence of anemia among adolescents is quite high in developing countries, including Indonesia. This literature review identifies three main effective approaches to addressing anemia in adolescents, namely through dietary strategies, education, and supplementation.

Dietary Strategies

The dietary approach aims to increase iron intake through foods rich in this nutrient as well as support iron absorption with additional nutrients, such as

vitamin [40,40,51,64]. The body more easily absorbs heme iron from animal foods like red meat, poultry, and fish than non-heme iron from plant sources, according to previous studies. Additionally, plant-based foods rich in iron, such as dark leafy greens (spinach, kale), legumes, and grains, can also help increase hemoglobin levels when combined with vitamin sources [42,43,51,57,65,66]. For example, adding orange or tomato slices to a dish can enhance the absorption of non-heme iron. Research also suggests limiting the consumption of foods like tea and coffee that inhibit iron absorption, particularly during mealtimes. The tannins in tea and polyphenols in coffee can bind iron in the intestines and prevent its absorption [67]. Thus, maintaining a balanced diet and understanding the right food combinations are crucial in efforts to improve iron status in adolescents [68]. In addition to paying attention to iron sources, it is also important to identify other nutritional deficiencies that can worsen anemia, such as vitamin B12 and folic acid deficiencies [69,70]. Animal products generally contain vitamin B12, while green vegetables, legumes, and some fruits contain folic acid, both of which are crucial to producing healthy red blood cells [71]. Therefore, we should provide teenagers who follow a vegetarian or vegan diet with a deeper understanding of alternative nutritional intakes to maintain their blood health.

Educational Approach

Nutrition education also plays a central role in efforts to combat anemia, especially among adolescents who

are in a growth phase and often have less healthy eating preferences [72].

Table 1: Publications that met the criteria of PICOS approach

No	Author and date	Sample	Design	Outcome
1	Indriasari <i>et al.</i> , (2024) [33]	70 Adolescent girls	Quasi-experiment	Providing adolescent girls with multi-micronutrient supplements and video education is more effective for increasing hemoglobin levels than just providing supplements
2	Dewi <i>et al.</i> , (2023) [34]	56 Female students	Quasi-design research	Direct supervision of daily blood supplement tablet consumption during menstruation can increase hemoglobin levels in adolescent girls
3	Indriani <i>et al.</i> , (20019) [35]	50 Anemic adolescent females	Comparative design study	Nutrition education and Moringa leaf supplements increase Hb
4	Magfirah <i>et al.</i> , (2023) [36]	49 Adolescents	Quasi-design research	Educational media is more effective than e-posters in improving Hb levels
5	Ayupir <i>et al.</i> , (2019)[37]	51 Adolescent females	Randomized controlled trial	Zn+vit. C is more effective than vit C alone or with health education in increasing Hb levels.
6	Tandoh <i>et al.</i> , (2023) [38]	169 Adolescent females	Randomized controlled, open-label trial	Turkey berry-fortified biscuits improved Hb levels and cognitive performance
7	Wardhani <i>et al.</i> , (2024) [39]	61 Anemic females	Randomized controlled trial	Moringa leaves are more effective than iron in increasing Hb levels
8	Indraswari <i>et al.</i> , (2020) [40]	40 Anemic females	Quasi-experiment	Iron-folate supplementation effectively increases Hb during menstruation.
9	Sari <i>et al.</i> , (2022) [41]	37 Participants	Quasi-experiment	Iron tablet with and without short video education improve Hb levels.
10	Aisah <i>et al.</i> , (2022) [42]	44 Young women	Quasi-experiment	Ajwa dates increase Hb and ferritin levels.
11	Deepak, (2022) [43]	60 Anemic adolescent females	Randomized controlled trial	Wheatgrass juice improves Hb levels.
12	Utama <i>et al.</i> , (2023) [44]	97 Participants	Quasi -experiment	Nutrition education improves Hb levels
13	Nurjanah <i>et al.</i> , (2020) [45]	38 Adolescent females	Quasi-experiment	Long bean leaf extract and iron improves Hb status.
14	Penggalih <i>et al.</i> , (2021) [46]	29 Adolescent females	Controlled trial	Beet juice with FeSO ₄ improves Hb.
15	Rusdin <i>et al.</i> , (2021) [47]	70 Participants	Randomized trial	The PAKEM education is more effective than leaflets and audiovisual media.
16	Handayani <i>et al.</i> , (2022) [48]	30 Participants	Quasi-experiment	Iron with Ambon banana increases Hb levels.
17	Rahmiwati <i>et al.</i> , (2023) [49]	126 Participants	Quasi-experiment	Culture-based nutrition education improves Hb levels.
18	Lauryn <i>et al.</i> , (2022) [50]	58 Participants	Quasi-experiment	Iron+vit C is more effective than iron alone for increasing Hb levels.
19	Handayani <i>et al.</i> , (2022) [51]	40 Adolescent females	Quasi-experiment	Fortified rice reduced anemia and Zn deficiency.
20	Mony <i>et al.</i> , (2022) [52]	26 Adolescent females	Quasi-experiment	Dates and bee pollen syrup improved erythrocyte index.
21	Ahmad Fuzi & Mushtaq, (2020) [53]	50 Women	Experimental study	Vitamin D improves Hb and Hct.
22	Kausar <i>et al.</i> , (2023) [54]	30 Participants	Randomized controlled trial	Moderate physical activity improves Hb levels.
23	Rahma <i>et al.</i> , (2023) [55]	75 Teenage girls	Quasi -experiment	Nutrition education increases Hb levels.
24	Suryani <i>et al.</i> , (2023) [18]	20 Teenage girls	Quasi-experiment	Protein, vitamin C, and iron tablets improve Hb.
25	Aryani & Nuhriawangsa, (2024) [56]	87 Teenage girls	Quasi-experiment	Cava smoothies increase Hb levels.
26	Hasugian <i>et al.</i> , (2023) [57]	72 Anemic teenage girls	Quasi -experiment	Moringa biscuits increase Hb levels.
27	Olii <i>et al.</i> , (2022) [58]	35 Adolescent girls	Pilot study	Soy juice increases Hb levels.
28	Sangita <i>et al.</i> , (2024) [59]	40 Adolescent girls	Experimental design	Millet biscuits improve Hb levels.

Nutrition education aims to enhance understanding of the importance of nutritious foods, particularly those rich in iron and other vitamins that support hemoglobin formation [19]. The educational approach targets not only teenagers but also parents and educators, fostering a collective awareness that promotes healthy eating habits. Nutrition education programs that involve all family members can enhance collective awareness about the importance of preventing anemia [73,74]. Education for healthcare workers in schools, such as school nurses and teachers, can also have a positive impact in creating a school environment that supports healthy eating habits

[75]. For example, campaigns to choose healthy food in the school cafeteria or involving students in activities to cook healthy meals can enhance practical understanding of what is beneficial for their bodies. Furthermore, the literature suggests that teens should receive this knowledge in an engaging and relevant manner [14,76]. The use of social media, health applications, or interactive activities such as quizzes and competitions can be an effective way to disseminate information about nutrition [77]. Studies show that this approach successfully motivates teenagers to adopt better eating habits, especially if the educational material is delivered in a way that aligns

Supplementation

Supplementation intervention becomes an important option for adolescents who have already experienced iron deficiency at an acute or chronic level [10]. Iron supplementation, whether in the form of tablets or syrup, is an effective method for increasing hemoglobin levels in a relatively short period of time [52]. Iron supplements are often recommended for consumption in specific doses, especially for teenage girls who are more susceptible to anemia due to monthly menstruation. Several studies also demonstrate that combining iron with vitamin C to enhance absorption and other essential elements like vitamin A, which also supports blood health, will maximize the effectiveness of supplementation [78-80]. However, we must balance supplementation with proper dose monitoring, as high doses of iron can lead to side effects like constipation and stomach disturbances [81,82]. Additionally, it is important for medical professionals to ensure that supplementation does not cause iron overload, which can lead to serious conditions such as hemochromatosis [83,84]. There is a debate among scientists regarding the effectiveness of supplementation compared to dietary changes. Some researchers argue that dietary changes have better long-term impacts because they form sustainable habits [85,86]. However, supplementation remains necessary under certain conditions, particularly in cases of severe anemia, as a quick step to increase hemoglobin levels before fully implementing a balanced diet [87].

Integrated Approaches for Hemoglobin Improvement

Comprehensive Strategy for Hemoglobin Enhancement This literature review indicates that the most effective methods for addressing anemia in adolescents are a combination of dietary strategies, education, and supplementation [13]. The simultaneous implementation of these three strategies, or the combination of any two interventions, enhances iron status and establishes a foundation for behaviors conducive to long-term health. This method may provide sustainable solutions, as dietary interventions can cultivate healthy eating habits, education can improve adolescents' comprehension and awareness of iron's significance, and supplementation offers direct assistance in instances of acute deficiency [19,62]. The integration of these three methodologies produces a more significant effect in combating anemia by surmounting obstacles inherent in singular strategies, such as non-compliance or insufficient nutritional knowledge among adolescents [49,54]. Nutritional interventions specifically improve the natural absorption of iron from daily diets, promoting sustainability and fostering habits that persist into adulthood [40,41]. The integration of education fosters foundational knowledge that adolescents can utilize to enhance their dietary choices while also

augmenting awareness within familial and communal contexts [35]. Supplementation acts as a temporary intervention or "booster" that quickly improves anemia, especially in severe or chronic cases [88]. This is then followed by dietary changes and education to prevent the condition from recurring [36]. This multi-sectoral strategy aligns with WHO recommendations for addressing public health concerns through integrated methods, highlighting the importance of cross-sector collaboration [4,44]. This intervention necessitates the participation of multiple stakeholders, including families supplying nutritious diets, educational institutions endorsing nutrition education initiatives, and health agencies delivering supplementation and health condition oversight [85,89]. Engaging multiple sectors establishes an ecosystem that more effectively aids adolescents in adopting healthy habits [90,91]. For instance, assistance from educational institutions through the provision of nutritious meals in cafeterias or the implementation of ongoing nutrition education will foster coherence that enhances the beneficial effects of the interventions [92]. Moreover, this amalgamation of strategies mitigates the deficiencies of a singular approach, which frequently possesses restricted scope or efficacy [93]. Research shows dietary interventions are insufficient for adolescents without nutrition knowledge or support, and supplementation doesn't yield long-term effects unless combined with behavioral and dietary changes [94]. The combination of these three methodologies promotes sustainable impact, promoting healthy eating habits, nutritional understanding, and optimal physical conditions among adolescents. Research has demonstrated that this comprehensive approach can decrease the incidence of anemia and enhance long-term quality of life [88,95]. This intervention integrates education, nutrition, and supplementation to establish a holistic "support pattern" that addresses anemia as a physical ailment while simultaneously enhancing mental and social well-being through improvements in memory, concentration, and physical activity among adolescents [47,96]. The efficacy of this multi-sectoral strategy establishes a novel paradigm for combating anemia: all facets of adolescents' lives—family, school, and community—collaborate to prevent anemia and foster the development of enduring healthy habits into adulthood [38,97-99]. In the long term, the execution of this integrated strategy not only mitigates anemia but also fosters the development of a healthier, more productive, and more competitive generation [100]. This approach enables public health policies to create programs that prioritize prevention and empowerment over mere treatments or curative interventions.

Conclusion

This study demonstrates that a combination of dietary intervention, education, and supplementation effectively increases hemoglobin levels in adolescent girls at risk of anemia, thereby promoting sustainable improvements in adolescent health and

Conflict of interests

No conflict of interest was declared by the authors.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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