

The Relationship Between Nutrition Literacy, Iron-Rich Food Consumption Behavior, and Anemia Among Adolescent Girls

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ABSTRACT

Adolescent girls are vulnerable to anemia because rapid growth, menstrual blood loss, and inadequate dietary iron may coincide with limited capacity to obtain, understand, and apply nutrition information. Purpose: This structured narrative review examined the relationship between nutrition literacy, iron-rich food consumption behavior, and anemia among adolescent girls, with particular attention to evidence from Indonesia and comparable low- and middle-income settings. Methods: Searches were updated through 14 September 2026 in PubMed/MEDLINE, WHO publication repositories, and publisher-indexed records using concepts covering adolescent girls, anemia/hemoglobin, nutrition or health literacy, dietary quality/diversity, iron-rich foods, iron-folic acid supplementation, and nutrition education. Thirty references meeting the stated relevance criteria were narratively synthesized. Results: Higher nutrition literacy was generally associated with healthier food habits and better diet quality, but knowledge alone was not consistently associated with anemia. Indonesian evidence indicated that more frequent consumption of animal-source iron-rich foods was associated with lower anemia risk, whereas poor dietary quality, inadequate iron intake, and iron-inhibiting dietary practices were associated with anemia. Intervention evidence suggested that education was most useful when paired with practical food-based strategies, school meals, behavior-change support, digital reminders, or supplementation. Conclusion: The evidence supports an indirect pathway in which nutrition literacy may contribute to dietary and self-care behaviors that are relevant to anemia prevention, while food access, menstruation, infection, nutritional status, and supplementation may modify these associations.



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INTRODUCTION

Anemia in adolescent girls is a major nutrition and public-health concern because adolescence combines accelerated growth with increasing iron requirements, while the onset of menstruation adds a recurrent route of iron loss. Accurate classification is important: the World Health Organization (WHO) updated its guidance on hemoglobin cutoffs and measurement in 2024 to improve anemia assessment across populations (World Health Organization, 2024). WHO also emphasizes that anemia is multifactorial and should be addressed through integrated action on nutrition, infection and inflammation, gynecological causes, inherited disorders, and social determinants rather than through a single intervention (World Health Organization, 2023).

For menstruating women and adolescent girls, iron supplementation remains an important public-health strategy when indicated. WHO guidance supports daily iron supplementation in relevant settings and describes weekly iron-folic acid supplementation as a practical anemia-prevention approach for non-pregnant women and adolescent girls (World Health Organization, 2016, 2018). Nevertheless, supplementation programs operate within a broader behavioral environment. Adolescents must recognize anemia risk, understand iron-rich food sources, translate knowledge into food choices, and adhere to supplementation despite barriers such as side effects, misconceptions, limited food availability, and social influences.

Nutrition literacy can be understood as the capacity to access, comprehend, evaluate, and use nutrition information in everyday decisions. A systematic review by Fleary et al. (2018) found that adolescent health literacy was frequently associated with health behaviors, although measurement approaches varied. A more recent systematic review involving 37 cross-sectional studies and 71,558 adolescents similarly found that higher health literacy was generally associated with healthier behavior profiles, with comparatively consistent patterns for nutrition-related outcomes (Sukys et al., 2026). These findings provide a behavioral rationale for expecting nutrition literacy to influence dietary quality and, indirectly, anemia risk.

Direct evidence supports the literacy-to-diet pathway. Koca and Arkan (2021) reported a positive relationship between adolescent nutrition literacy and food habits, while Hoteit et al. (2022) showed that adolescent nutrition illiteracy coexisted with food insecurity and adverse nutrition outcomes in a national sample of parent-adolescent dyads. Ashoori et al. (2023) further found that food and nutrition literacy predicted diet quality and nutrient density, with the skill dimension showing a stronger contribution than knowledge alone. In an intervention context, health-literacy-grounded web education improved adolescent nutrition and exercise behaviors, illustrating that literacy can be operationalized as a modifiable determinant rather than merely a background characteristic (Dülger & Ayaz-Alkaya, 2024).

However, the link from nutrition knowledge to anemia is not necessarily direct. In West Java, anemia affected a substantial proportion of school-going adolescent girls and was associated with

lower dietary quality and lower consumption of meat, chicken, and fish (Agustina et al., 2020). Yet, in the same general population, low-to-moderate anemia-related knowledge, attitude, and practice scores were not significantly associated with anemia after adjustment (Agustina et al., 2021). This apparent inconsistency suggests a critical research gap: nutrition literacy may affect anemia mainly when it changes actual dietary behavior, supplement adherence, or other protective practices.

However, evidence linking nutrition literacy directly with anemia is less consistent. In Indonesian adolescent girls, diet quality and consumption of meat, chicken, and fish were associated with anemia, whereas anemia-related knowledge, attitudes, and practices were not significantly associated with anemia after adjustment (Agustina et al., 2020, 2021). This indicates a gap between knowing about anemia prevention and achieving measurable dietary or hematologic outcomes. The present review addresses this gap by integrating evidence across the literacy-to-behavior and behavior-to-anemia pathways. It asks whether nutrition literacy is associated with healthier food behavior, whether iron-rich food consumption and dietary quality are associated with anemia, and which contextual factors may modify these relationships.

METHODS

A structured narrative review was conducted to synthesize evidence relevant to the relationship between nutrition literacy, iron-rich food consumption behavior, and anemia among adolescent girls. Searches were updated through 14 September 2026 using PubMed/MEDLINE, WHO publication repositories, and publisher-indexed records identified through targeted searches. Search concepts combined terms for adolescents or adolescent girls with anemia or hemoglobin, nutrition literacy or health literacy or knowledge-attitude-practice, iron-rich foods or dietary diversity or diet quality, and iron-folic acid supplementation or nutrition education. An example search structure was: (adolescent* OR “adolescent girls”) AND (anemia OR haemoglobin) AND (“nutrition literacy” OR “health literacy” OR knowledge OR attitude OR practice) AND (iron-rich foods OR “dietary diversity” OR “diet quality”) AND (iron-folic acid OR nutrition education).

Priority was given to peer-reviewed studies published from 2018 to 2026, while earlier WHO guidance was retained when directly relevant to prevention practice. Evidence was considered eligible when it involved adolescents and assessed at least one of the following: nutrition/health literacy, anemia-related knowledge or behavior, dietary quality or diversity, iron-rich food consumption, iron-folic acid adherence, hemoglobin, iron status, or anemia. Studies focused exclusively on unrelated chronic diseases, pregnancy, or adult populations were excluded from the empirical synthesis. Records were considered relevant when the population, exposure or intervention, and anemia- or nutrition-related outcome matched the review question; potentially relevant reports were then assessed for sufficient information on study design, participants, measures, and findings.

Thirty references were included in the final narrative synthesis, comprising peer-reviewed studies and directly relevant WHO guidance, with deliberate inclusion of Indonesian evidence because its dietary and program context is particularly relevant. Methodological relevance and credibility were considered narratively by examining study design, population/sample description,



clarity of exposure or intervention measurement, outcome measurement, and whether the reported analysis was appropriate to the study design. No standardized risk-of-bias score was assigned because the evidence was methodologically heterogeneous and the review was designed as a structured narrative synthesis rather than a formal systematic review; instead, study limitations and design-specific threats to inference were explicitly considered during interpretation, particularly for cross-sectional and non-randomized studies. Data were extracted narratively for setting, design, sample, exposure/intervention, and key nutrition or anemia outcomes. Because the included studies used heterogeneous literacy instruments, diet measures, intervention packages, and anemia definitions, no pooled meta-analysis was performed. Findings were synthesized into a conceptual pathway from literacy to behavior to anemia-related outcomes, while potential modifiers such as food security, menstrual blood loss, dietary diversity, infection, and supplementation were considered. As this manuscript synthesizes published literature and does not involve primary human participants or identifiable data, institutional ethical approval was not required.

RESULTS

1. Nutrition Literacy and Food-Choice Behavior

Across the literacy literature, higher nutrition or health literacy was more often associated with favorable food behavior than with unfavorable behavior. Koca and Arkan (2021) reported a positive association between nutrition literacy and healthy food habits in adolescents. Hoteit et al. (2022) reported that approximately 45% of adolescents in their Lebanese sample were nutritionally illiterate and that nutrition literacy was intertwined with food-security conditions, emphasizing that literacy is both an individual capability and a resource-dependent determinant. Because these findings are largely observational, they indicate association rather than a causal effect of literacy on food choice.

Ashoori et al. (2023) provided an important refinement: practical food and nutrition skills were stronger predictors of diet quality and nutrient density than knowledge alone. This distinction is relevant to anemia prevention because identifying iron-rich foods does not necessarily result in regular consumption if adolescents cannot select, obtain, prepare, combine, or afford them. The randomized study by Dülger and Ayaz-Alkaya (2024) provides intervention evidence that literacy-oriented education can modify nutrition behavior. Taken together, the evidence supports an association between literacy and food behavior, while suggesting that functional and interactive skills may be more relevant than factual recall.

2. Iron-Rich Foods, Diet Quality, and Anemia

Indonesian studies provide evidence for the association between dietary behavior and anemia-related outcomes. Knijff et al. (2021) analyzed 2,150 adolescents and found that frequent consumption of animal-based iron-rich foods was associated with lower anemia risk among girls (PR = 0.59; 95% CI: 0.36-0.97). Agustina et al. (2020) similarly observed that non-anemic girls had higher diet-quality scores and that lower consumption of meat, chicken, and fish was associated with anemia. These cross-sectional findings indicate that the source and regularity of iron intake are

associated with anemia status, but they cannot establish that dietary behavior caused the observed differences.

Local dietary patterns can further shape iron bioavailability. Rahfiludin et al. (2021), studying Sundanese adolescent girls in Islamic boarding schools, reported low total iron intake and found that heme iron and iron from meat, fish, and poultry correlated with hemoglobin and hematocrit. Wati et al. (2023) found that adolescent dietary behavior and consumption of iron inhibitors were associated with anemia in Banyumas, reinforcing the importance of both iron sources and meal composition. These results are biologically plausible because heme iron is generally more bioavailable, whereas dietary inhibitors can reduce non-heme iron absorption.

Broader evidence supports the role of dietary diversity. Li et al. (2025), in a systematic review and meta-analysis, reported that low dietary diversity was associated with higher odds of anemia among children and adolescents aged 6-18 years (OR = 1.73; 95% CI: 1.27-2.36). In Ethiopia, Berhe et al. (2022) found that inadequate dietary diversity, prolonged menstrual blood flow, food insecurity, low body mass index, and intestinal parasites were among factors associated with anemia in adolescent girls. These findings indicate that iron-rich food behavior operates within a broader nutritional and biological system.

3. Knowledge Alone Does Not Guarantee a Better Hemoglobin Outcome

Evidence also shows why a simple knowledge-anemia model is inadequate. Agustina et al. (2021) reported that low-to-moderate anemia-related KAP scores were not significantly associated with anemia among Indonesian adolescent girls (AOR = 1.26; $p = .43$), despite a high anemia burden in the study sample. In Telangana, Kamble et al. (2024) found a high anemia prevalence while only 27.6% of girls were aware of iron-rich foods; this demonstrates a knowledge gap, but the cross-sectional design cannot establish that low awareness caused anemia.

Ghimire et al. (2024) found that poor anemia knowledge, incomplete iron-folic acid intake, and absence of dietary diversity were each associated with higher anemia prevalence among school-going adolescent girls in Nepal. This pattern is compatible with a mediated pathway in which literacy may facilitate protective behavior, while adherence and actual dietary diversity are more proximal to hemoglobin status. However, mediation cannot be established from these cross-sectional associations. Interventions should therefore assess whether knowledge is translated into sustained behavior rather than relying on post-education knowledge scores alone.

4. Interventions That Connect Literacy With Action

Intervention studies strengthen the argument that education works best when combined with behavioral opportunities. Seminar et al. (2020) documented misinformation and low perceived anemia risk among Indonesian girls and parents, showing that family and sociocultural beliefs can undermine preventive behavior. Oddo et al. (2022) evaluated a gender-responsive Indonesian package combining school nutrition education, behavior-change communication, breakfast, and weekly iron-folic acid supplementation and found improvements in nutrition knowledge, selected dietary behaviors, physical activity, and reported weekly supplementation among girls.



Rimbawan et al. (2023) evaluated an integrated food-and-education model in an Indonesian Islamic boarding school. A school lunch program combined with nutrition education was accompanied by improvements in knowledge, attitudes, practices, and protein, iron, and vitamin C intake; anemia prevalence in the assessed subgroup declined from 42.6% to 21.7% over the study period. Suciyanti et al. (2025) likewise reported increased consumption of animal protein, liver, plant protein, vegetables, and iron intake after a 20-week school-based program in East Java. These intervention findings suggest that literacy may have greater practical relevance when adolescents receive concrete, locally feasible opportunities to act, although study design and contextual factors should be considered when interpreting changes in anemia.

Digital strategies may also support action. Pasamba et al. (2026) reported improved anemia knowledge and weekly iron-folic acid adherence among adolescent girls in Maluku; anemia prevalence in the intervention school decreased from 35.0% to 17.5% during the short intervention period, although the non-randomized design and small sample limit causal interpretation. Outside Indonesia, Abu-Baker et al. (2021) reported improvements in anemia-related knowledge, attitudes, and practices following school-based nutrition education among female adolescents in Jordan. Ghadam et al. (2023) reported improvements in knowledge, attitudes, practices, and selected iron-deficiency-anemia indicators after a digital game-based nutrition education intervention. Vasquez-Mamani et al. (2025) similarly reported improvements in knowledge, attitudes, dietary practices, and hemoglobin after a 16-week nutrition education program among female Peruvian adolescents.

Supplementation trials show that biological response remains context dependent. Cliffer et al. (2023) found modest hemoglobin improvement with weekly iron-folic acid supplementation among adolescents in Burkina Faso but no strong reduction in anemia outcomes, suggesting that supplementation alone may be insufficient when anemia has multiple causes. In Zanzibar, Cliffer et al. (2025) found that daily multiple micronutrients reduced the risk of moderate or severe anemia overall, whereas weekly iron-folic acid did not significantly reduce anemia compared with control. These results reinforce WHO's multifactorial framework and argue for pairing supplementation with dietary, behavioral, and context-specific measures.

Table 1. Selected Evidence Linking Nutrition Literacy, Dietary Behavior, and Anemia-Related

Study	Design / population	Outcomes	
		Exposure or intervention	Key finding relevant to the pathway
Koca & Arkan (2021)	Cross-sectional adolescents	Nutrition literacy and food habits	Higher nutrition literacy was positively related to healthier food habits.
Hoteit et al. (2022)	National cross-sectional, 450 parent-adolescent dyads	Adolescent nutrition literacy and parental food literacy	Nutrition illiteracy coexisted with food insecurity and adverse nutrition outcomes, including anemia in the sample.

Agustina et al. (2020)	Cross-sectional, 335 Indonesian girls	Diet quality, diversity, meal patterns	Higher diet quality characterized non-anemic girls; lower meat/chicken/fish intake correlated with anemia.
Knijff et al. (2021)	Cross-sectional, 2,150 Indonesian adolescents	Animal-source iron-rich foods	Frequent intake was associated with lower anemia risk among girls (PR 0.59).
Rimbawan et al. (2023)	Pre-post school intervention, Indonesia	School lunch + nutrition education	Improved KAP and nutrient intake; anemia in the assessed subgroup fell from 42.6% to 21.7%.
Suciyanti et al. (2025)	School-based intervention, East Java	Optimized food-based recommendations	Increased animal protein, liver, vegetables, and iron intake.
Ghimire et al. (2024)	Cross-sectional, 405 Nepalese girls	Knowledge, IFA intake, dietary diversity	Poor knowledge, incomplete IFA intake, and absent dietary diversity were associated with higher anemia prevalence.
Li et al. (2025)	Systematic review/meta-analysis	Dietary diversity	Low dietary diversity increased odds of anemia among ages 6-18 (OR 1.73).
Pasamba et al. (2026)	Quasi-experimental, 82 Indonesian girls	Digital anemia education + IFA reminders	Improved knowledge and IFA adherence; anemia decreased in the intervention school.
Cliffer et al. (2023; 2025)	Cluster-randomized school trials	IFA or multiple micronutrients	Effects on anemia varied by setting and regimen, indicating need for complementary interventions.

5. Integrated Interpretation of the Evidence

The evidence supports an indirect, non-deterministic pathway. Nutrition literacy may influence how adolescents interpret anemia risk, identify iron-rich foods, understand enhancers and



inhibitors of iron absorption, plan meals, and adhere to iron-folic acid supplementation. These behaviors are then associated with dietary iron exposure and, together with menstrual losses, infection, inflammation, total diet quality, and baseline nutritional status, may contribute to hemoglobin and anemia outcomes. The mixed result reported by Agustina et al. (2021) illustrates that knowledge may be too distal from hemoglobin to show a detectable association unless food access and behavior also change. Because most evidence is observational, this pathway should be treated as a conceptual model rather than a demonstrated causal chain.

DISCUSSION

This review indicates that nutrition literacy may function as an upstream factor in anemia prevention among adolescent girls, but the available evidence does not establish a direct biological effect. The most consistent evidence concerns two adjacent associations: higher literacy is associated with healthier food behavior, and more frequent consumption of iron-rich foods or better dietary quality is associated with more favorable anemia-related outcomes. Evidence directly connecting a validated nutrition-literacy score with measured hemoglobin in adolescent girls remains limited. These findings support further longitudinal and intervention research rather than a causal interpretation of the current evidence.

The distinction between declarative knowledge and functional skill helps explain the observed pattern. Adolescents may know that liver, meat, fish, poultry, legumes, or green vegetables contain iron but still be unable to consume them regularly because of cost, school food environments, household food insecurity, taste preferences, body-image concerns, or family norms. Likewise, girls may understand the benefit of weekly iron-folic acid tablets but discontinue them because of side effects, forgetting, low perceived risk, or misinformation. Therefore, anemia-prevention education should train practical skills: recognizing affordable local iron sources, composing meals, combining non-heme iron sources with vitamin C-rich foods, avoiding strong iron inhibitors around iron-rich meals or supplementation, and responding to common side effects or adherence barriers.

The Indonesian evidence is particularly relevant. Studies from West Java, East Java, Central Java/Banyumas, Maluku, Lombok, and other settings show that anemia prevention needs to be culturally and operationally grounded. Programs in the reviewed literature combined education with school meals, social behavior-change communication, optimized food-based recommendations, digital reminders, or weekly supplementation. Such combined approaches provide practical opportunities for adolescents to translate information into behavior, although the relative contribution of each component cannot be separated consistently across studies. Parent and peer involvement may also matter because adolescents do not make food and health decisions in isolation.

An additional implication is that anemia should not be equated automatically with iron deficiency. WHO's comprehensive framework recognizes multiple nutritional and non-nutritional causes (World Health Organization, 2023). Menstrual blood loss, infection and inflammation, inherited hemoglobin disorders, other micronutrient deficiencies, and food insecurity can alter the relationship between diet and hemoglobin. Consequently, programs should combine nutrition

literacy and food-based strategies with appropriate screening, treatment, menstrual-health support, deworming or infection control where indicated, and access to health services.

For research, most included studies measured anemia status or prevalence rather than new-onset anemia over time. A prospective cohort would therefore be needed to estimate true incidence and establish temporality. Future studies should use validated nutrition-literacy instruments, repeated dietary assessment, objective supplement-adherence measures, and biomarkers that distinguish iron deficiency from other causes of anemia, such as ferritin interpreted alongside inflammation markers. Mediation analysis could then test whether iron-rich food behavior statistically mediates the association between nutrition literacy and anemia.

This review has several limitations. It was structured and evidence focused but was not designed as a fully exhaustive systematic review with duplicate screening or formal standardized risk-of-bias scoring. The narrative relevance and credibility assessment was used to support interpretation, but it does not provide the same reproducibility as a formal systematic-review appraisal. Included studies varied in age range, anemia definition, dietary assessment, literacy measurement, and intervention intensity. Many key studies were cross-sectional, limiting causal inference, and several intervention studies were non-randomized or had short follow-up. Nevertheless, the convergence of literacy, dietary, Indonesian, intervention, and meta-analytic evidence provides a coherent basis for a testable conceptual model and for designing integrated adolescent-anemia programs.

CONCLUSIONS

Nutrition literacy, iron-rich food consumption behavior, and anemia among adolescent girls are linked through an evidence-supported multistep association. Higher nutrition literacy is generally associated with healthier food choices, while frequent consumption of iron-rich foods, better dietary quality, and greater dietary diversity are associated with lower anemia risk or more favorable hemoglobin outcomes. However, literacy alone does not guarantee protection from anemia because knowledge must be translated into sustained behavior and may be modified by food access, menstrual blood loss, infection, nutritional status, and adherence to supplementation. The reviewed evidence therefore supports integrated interventions and further longitudinal research to clarify temporality and causal pathways.

Programs for adolescent girls should combine functional nutrition literacy with practical access to affordable iron-rich foods, school-based behavior support, attention to vitamin C and iron inhibitors, menstrual-health education, and appropriate iron-folic acid supplementation. Future longitudinal studies should measure nutrition literacy, actual food behavior, iron status, and incident anemia in the same cohort to clarify the temporal and causal pathway.

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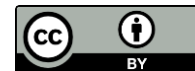
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