



Determinants of Hemoglobin Levels Among Adolescent Girls: A Cross-Sectional Study in Indonesia

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Article Information	ABSTRACT
Received : 18 June 2026 Revised : 03 August 2026 Accepted : 18 August 2026	Anemia remains a major public health problem among adolescent girls and may impair physical health, cognitive performance, and quality of life. Multiple behavioral and biological factors, including dietary habits, sleep quality, physical activity, stress, menstrual patterns, and knowledge about anemia, have been proposed as potential determinants. This study aimed to analyze the determinants associated with anemia among adolescent girls. A quantitative study with a cross-sectional design was conducted among 150 tenth-grade female students selected from a population of 216 students using the Slovin formula. Data were collected through hemoglobin measurements using a digital hemometer and validated questionnaires assessing dietary habits, sleep quality, physical activity, stress, menstrual patterns, and knowledge about anemia. Data were analyzed using the Chi-square test. Of the 150 participants, 31 (20.7%) were classified as anemic. No significant associations were found between anemia and dietary habits ($p = 0.234$), sleep quality ($p = 0.354$), physical activity ($p = 0.346$), stress ($p = 0.653$), menstrual patterns ($p = 0.184$), or knowledge about anemia ($p = 0.904$). In conclusion, none of the examined factors were significantly associated with anemia among adolescent girls. These findings suggest that anemia is likely influenced by other biological, nutritional, and socioeconomic factors that were not assessed in this study.
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Introduction

Anemia remains a major public health problem worldwide, particularly among women of reproductive age, including adolescent girls (Gardner et al., 2023). Anemia is characterized by a hemoglobin concentration below the normal threshold for age, sex, and physiological status, thereby reducing the blood's capacity to transport oxygen (World Health Organization, 2023). Global evidence continues to demonstrate the substantial burden of anemia among adolescents and women of reproductive age. In Indonesia, the prevalence of anemia among adolescents has been reported to be approximately 32%, indicating that nearly one in three adolescents is affected (R. P. Sari et al., 2023). In West Java, approximately 40% of adolescent girls have been reported to experience anemia (Oktavia et al., 2024), further demonstrating the importance of anemia as a continuing public health concern in this population.

Anemia during adolescence may have important consequences for physical and cognitive development, physical capacity, academic performance, and quality of life (Sigit et al., 2024). In addition, anemia during adolescence may have implications beyond the adolescent period because adolescent girls will become future mothers, and poor nutritional and health status before pregnancy may contribute to adverse maternal and birth outcomes, including low birth weight and intergenerational nutritional problems (Puspitasari et al., 2022). Therefore, identifying the factors associated with anemia among adolescent girls is important not only for individual health but also for strengthening preventive interventions during a critical stage of the life course.

The occurrence of anemia among adolescent girls is influenced by multiple and potentially interacting factors rather than by a single cause. The WHO Comprehensive Framework for Action on Anaemia emphasizes that effective anaemia reduction requires the assessment of the multiple causes and risk factors contributing to anaemia and the coordination of interventions across health and other sectors (World Health Organization, 2023). Within this framework, the factors examined in the present study represent several relevant domains. Menstrual patterns may contribute to iron loss through menstrual bleeding, while dietary patterns may influence the availability of nutrients required for erythropoiesis. Lifestyle factors, including sleep quality and physical activity, may also be related to physiological health and nutritional status. Psychosocial stress may affect health through behavioral and physiological pathways, whereas knowledge may influence preventive behaviors related to diet and iron supplementation. Thus, the WHO framework provides a conceptual basis for examining anemia as a multidimensional

outcome resulting from the interaction of biological, nutritional, behavioral, and psychosocial factors.

Although these domains are theoretically relevant, previous empirical studies have reported inconsistent findings regarding their associations with anemia among adolescent girls. For example, studies have reported significant associations between dietary or nutritional factors and anemia, including the relationship of nutritional status, protein intake, and iron intake with hemoglobin-related outcomes among adolescent girls (Pibriyanti et al., 2025). Similarly, some studies have identified an association between sleep quality and anemia-related outcomes, whereas other studies using broader populations or different measurement approaches have found no significant association between anemia status and sleep quality (Fitria & Puspita, 2020; Helmyati et al., 2023). Findings regarding knowledge have also varied. Although some studies have reported a significant relationship between knowledge about anemia and hemoglobin status (Utami et al., 2022), other research has found that knowledge, attitudes, and practices were not significantly associated with anemia prevalence among Indonesian adolescent girls (Agustina et al., 2021). Physical activity has also yielded inconsistent findings. While some studies have reported that higher levels of physical activity are associated with better hemoglobin levels among adolescent girls (Pibriyanti et al., 2025), other studies have found no significant association between physical activity and anemia incidence (Putri & Fauziyah, 2023).

These inconsistencies may be explained by differences in population characteristics, geographic context, sample size, study design, operational definitions, and measurement methods. According to the WHO comprehensive framework for anemia, anemia is a multifactorial condition influenced by interactions among biological, nutritional, infectious, reproductive, behavioral, and social determinants, and the relative contribution of these factors may vary across populations and settings (World Health Organization, 2023). In addition, studies conducted in different regions may involve adolescent girls with different dietary patterns, adherence to iron supplementation, menstrual characteristics, socioeconomic backgrounds, and access to health information, all of which may influence anemia risk. Furthermore, previous studies have used different indicators to assess anemia and its potential determinants, including hemoglobin concentration, anemia status, dietary intake, self-reported health behaviors, and standardized assessment instruments. Variations in study design and measurement approaches may also contribute to inconsistent findings because differences in

hemoglobin assessment methods, diagnostic criteria, and exposure measurements can affect the identification of anemia and its associated determinants (Garcia-casal et al., 2023). Consequently, factors associated with anemia in one population may not demonstrate similar associations in another population because of contextual and methodological differences.

Taken together, these inconsistent findings indicate that the current evidence remains inconclusive regarding whether commonly proposed determinants consistently contribute to anemia among adolescent girls across different settings. Although the WHO Comprehensive Framework for Action recognizes anemia as a multifactorial condition resulting from interactions among biological, nutritional, infectious, reproductive, behavioral, and social determinants (World Health Organization, 2023), previous studies have often examined these determinants individually or have reported conflicting findings regarding the contribution of specific nutritional, biological, lifestyle, psychosocial, and knowledge-related factors to anemia among adolescent girls (Wiafe et al., 2023). Consequently, limited evidence is available regarding whether these determinants demonstrate consistent associations when evaluated simultaneously within the same adolescent population and contextual setting. The present study addresses this gap by examining multiple domains of potential determinants including dietary patterns, sleep quality, stress, physical activity, menstrual patterns, and knowledge within a single school-based population of adolescent girls. Rather than assuming that all theoretically relevant factors are significant predictors, this study provides an empirical assessment of whether determinants from different domains are associated with anemia within a specific adolescent population.

Method

This quantitative study employed a cross-sectional design to examine the determinants of anemia among 10th-grade female students at MAN 1 Bandung. The study population consisted of 216 students, and a sample of 150 respondents was selected using the Slovin formula with a 5% margin of error based on the established inclusion criteria. Data were collected at a single point in time using structured questionnaires and hemoglobin (Hb) measurements obtained with a digital hemometer to determine anemia status. The independent variables included dietary patterns, sleep quality, stress levels, physical activity, menstrual patterns, and knowledge about anemia, which were assessed using validated questionnaires, including the Pittsburgh Sleep Quality Index (PSQI), the Kessler Psychological Distress Scale (K10), the Physical Activity

Questionnaire for Adolescents (PAQ-A), and questionnaires adapted from previous studies. Data were analyzed using SPSS through univariate, bivariate (Chi-square), and multiple logistic regression analyses to identify factors associated with anemia among adolescent girls. Ethical approval for this study was obtained from the Health Research Ethics Committee of the Faculty of Health Sciences and Technology, Jenderal Achmad Yani University (No. 09/KEPK/FITKes-Unjani/I/2026).

Research Results

A total of 150 adolescent girls participated in this study. The prevalence of anemia among respondents was determined based on hemoglobin measurements, while the independent variables included dietary patterns, sleep quality, physical activity, menstrual patterns, knowledge about anemia, and stress levels.

Table 1. Characteristics of Respondents (n = 150)

No	Variable	Category	F	%
1	Dietary Pattern	Good	82	54.7
		Poor	68	45.3
2	Sleep Quality	Good	2	1.3
		Poor	148	98.7
3	Physical Activity	Light	118	78.7
		Moderate	30	20.0
		Vigorous	2	1.3
4	Menstrual Pattern	Normal	69	46.0
		Abnormal	81	54.0
5	Knowledge	Good	103	68.7
		Fair	33	22.0
		Poor	14	9.3
6	Stress Level	High	93	62.0
		Moderate	48	32.0
		Low	9	6.0

The results showed that most respondents had good dietary patterns (54.7%), poor sleep quality (98.7%), light physical activity (78.7%), abnormal menstrual patterns (54.0%), good knowledge regarding anemia (68.7%), and high stress levels (62.0%).

Table 2. Bivariate Analysis of Factors Associated with Anemia among Adolescent Girls

No	Variable	p-value
1	Dietary Pattern	0.234
2	Sleep Quality	0.354
3	Physical Activity	0.346
4	Menstrual Pattern	0.184
5	Knowledge	0.904
6	Stress Level	0.653

Bivariate analysis showed that there were no significant associations between dietary patterns ($p = 0.234$), sleep quality ($p = 0.354$), physical activity ($p = 0.346$), menstrual patterns ($p = 0.184$), knowledge ($p = 0.904$), or stress levels ($p = 0.653$) and the occurrence of anemia among adolescent girls. All variables had p-values greater than 0.05, indicating that none met the criterion for statistical significance. Because no variable met the criteria for inclusion in multivariate analysis, further logistic regression analysis was not performed.

Discussion

This study aimed to identify the determinants of anemia among adolescent girls by examining the associations between dietary patterns, sleep quality, physical activity, menstrual patterns, knowledge about anemia, and stress levels. The findings demonstrated that none of the investigated variables were significantly associated with anemia ($p > 0.05$). Rather than indicating that these factors are unimportant, these results suggest that anemia among adolescent girls cannot be adequately explained by a single behavioral, biological, or psychosocial determinant measured independently. Instead, the findings reinforce the concept that anemia is a multifactorial condition resulting from the interaction of multiple determinants operating simultaneously. Therefore, the study objective was achieved by demonstrating that the occurrence of anemia among adolescent girls is likely influenced by a complex interplay of nutritional, physiological, behavioral, and environmental factors rather than isolated risk factors. This interpretation is consistent with the WHO Comprehensive Framework for Action on Anaemia, which emphasizes that anemia develops through interconnected immediate, underlying, and enabling determinants, including dietary inadequacy, infections, inflammation, reproductive health, socioeconomic conditions, and health-service factors (World Health Organization, 2023). Zutphen et al. (2021) highlighted that the etiology of anemia among

Indonesian adolescents remains incompletely understood because multiple biological and contextual factors interact to influence hemoglobin status.

From a theoretical perspective, the findings of this study partially support existing theories regarding the determinants of anemia while also highlighting the complexity of their interactions. The Iron Bioavailability Theory explains that dietary intake contributes to hemoglobin synthesis through the absorption and utilization of iron, suggesting that inadequate iron intake increases the risk of iron deficiency anemia (Pasricha et al., 2021). Likewise, the Menstrual Blood Loss Theory proposes that excessive menstrual blood loss is one of the major contributors to depleted iron stores among adolescent girls and women of reproductive age (Mansour et al., 2021). Furthermore, Physiological Adaptation Theory suggests that lifestyle-related factors, including sleep quality and physical activity, may influence erythropoiesis through hormonal regulation, energy metabolism, and inflammatory responses (Vanhie & Lisio, 2022). The Health Belief Model also proposes that adequate knowledge may encourage preventive behaviors, including consuming iron-rich foods and adhering to iron supplementation programs (Silitong et al., 2023). Nevertheless, the present findings indicate that these theoretical pathways may not operate independently but instead interact with broader determinants, including iron bioavailability, nutritional status, inflammatory conditions, genetic factors, adherence to iron supplementation, and socioeconomic circumstances. This interpretation is consistent with the WHO Comprehensive Framework for Action on Anaemia, which recognizes anemia as a multifactorial condition requiring comprehensive rather than single-factor explanations (World Health Organization, 2023).

The absence of a significant association between dietary patterns and anemia suggests that general dietary behavior may not adequately represent the amount of iron that is ultimately absorbed and utilized by the body. Although dietary intake is widely recognized as a key determinant of hemoglobin synthesis, assessments based solely on general eating patterns may overlook important aspects of iron nutrition, including heme iron intake, iron bioavailability, vitamin C consumption, and dietary inhibitors such as phytates and tannins (Piskin et al., 2022). In addition, the relatively homogeneous dietary patterns observed among respondents may have reduced variability between exposure groups, thereby limiting the ability to detect statistically significant associations. These findings are consistent with (Rosida & Dwihesti (2020), who reported that relatively homogeneous dietary habits among adolescents were not significantly

associated with anemia status. Likewise, Zutphen et al. (2021) emphasized that iron deficiency alone does not explain all anemia cases among Indonesian adolescents because nutritional deficiencies often coexist with inflammation, infections, inherited hemoglobin disorders, and other biological conditions. Therefore, the present findings support the view that assessments focusing exclusively on general dietary patterns may underestimate the complexity of nutritional determinants contributing to anemia.

Similarly, menstrual patterns were not significantly associated with anemia, despite more than half of the respondents reporting abnormal menstrual cycles. This finding suggests that menstrual cycle characteristics alone may not accurately reflect the actual volume of menstrual blood loss, which is the principal biological mechanism contributing to iron depletion. Previous studies have demonstrated that menstrual regularity and cycle length are not always reliable indicators of menstrual blood loss because bleeding volume may also be influenced by ovulatory function, endocrine regulation, coagulation disorders, and underlying gynecological conditions (Munro et al., 2023). Moreover, adequate dietary iron intake, sufficient iron stores, and adherence to iron supplementation may compensate for menstrual iron loss, thereby weakening the observable association between menstrual characteristics and anemia. Similar findings were reported by (P. Sari et al., 2022), who observed that anemia among adolescent girls in West Java was influenced by multiple nutritional and health-related factors rather than menstrual characteristics alone. Collectively, these findings further support the WHO Comprehensive Framework for Action on Anaemia, which emphasizes that reproductive health factors should be interpreted alongside nutritional, biological, and environmental determinants to better explain the occurrence of anemia among adolescent girls.

Regarding lifestyle factors, neither sleep quality nor physical activity was significantly associated with anemia among adolescent girls. Although Physiological Adaptation Theory suggests that adequate sleep and regular physical activity contribute to physiological homeostasis, erythropoiesis, and iron metabolism, these mechanisms are generally influenced by the duration, intensity, and chronicity of exposure rather than by behavioral status measured at a single point in time (Vanhie & Lisio, 2022). Consequently, the absence of significant associations in the present study does not necessarily contradict existing physiological theories but rather suggests that the influence of these lifestyle factors may depend on broader biological and nutritional conditions. One possible explanation is the relatively homogeneous distribution

of these variables, as nearly all respondents reported poor sleep quality and most engaged in light physical activity, thereby reducing variability between comparison groups and limiting the statistical power to detect meaningful associations. Furthermore, sleep quality and physical activity may indirectly influence hemoglobin levels through nutritional status, inflammation, body composition, or overall health rather than through direct physiological pathways. These findings are consistent with Putri & Fauziyah (2023), who reported no significant association between physical activity and anemia among Indonesian adolescent girls, and Anggita & Anwar (2023), who found that sleep quality alone was not independently associated with anemia status. Collectively, these findings reinforce the WHO Comprehensive Framework for Action on Anaemia, which recognizes lifestyle behaviors as interacting determinants whose effects are modified by nutritional, biological, and environmental factors rather than acting independently (Zutphen et al., 2021)

Knowledge about anemia and stress levels were likewise not significantly associated with anemia. This finding is consistent with the Health Belief Model, which proposes that knowledge alone is insufficient to improve health outcomes unless it is translated into sustained behavioral changes supported by motivation, self-efficacy, perceived susceptibility, and enabling environmental factors. Although most respondents demonstrated good knowledge regarding anemia, such knowledge may not have resulted in adequate dietary practices, regular iron supplementation, or other preventive behaviors capable of improving hemoglobin status. Similarly, psychological stress may influence iron metabolism through activation of neuroendocrine and inflammatory pathways; however, these physiological effects are generally observed under prolonged or severe stress conditions and may not be adequately reflected through cross-sectional assessment (Reid & Georgieff, 2023). These findings suggest that knowledge alone may not be sufficient to improve hemoglobin status or reduce anemia unless it is accompanied by sustained behavioral changes, nutritional interventions, and continuous health promotion. Therefore, anemia education should be integrated with comprehensive health promotion strategies to achieve meaningful improvements in anemia prevention among adolescent girls (Dewi et al., 2025). Therefore, the present findings further support the notion that behavioral and psychosocial determinants should be interpreted within broader biological and contextual pathways rather than as independent predictors of anemia.

An important and somewhat unexpected finding was that variables commonly considered major contributors to anemia, particularly dietary patterns and menstrual patterns, were not significantly associated with anemia status. Rather than contradicting previous evidence, these findings suggest that broad behavioral indicators may not adequately capture the biological mechanisms underlying anemia. More specific indicators, including dietary iron intake, iron bioavailability, heavy menstrual bleeding, serum ferritin concentration, inflammatory biomarkers, adherence to iron supplementation, and genetic factors affecting iron metabolism, may provide greater explanatory power. Similar conclusions were reported by van Zutphen et al. (2021), who identified substantial knowledge gaps regarding the etiology of anemia among Indonesian adolescents and emphasized that iron deficiency alone does not explain all anemia cases. The WHO Comprehensive Framework for Action on Anaemia likewise recognizes that anemia results from interactions among nutritional deficiencies, infectious diseases, reproductive health, environmental conditions, and health-system factors (World Health Organization, 2023). Consequently, the present findings contribute to the growing body of evidence demonstrating that anemia among adolescents is highly context-dependent and should be investigated using comprehensive multidimensional approaches rather than isolated risk-factor models.

The novelty of this study lies in its comprehensive evaluation of biological, behavioral, and psychosocial determinants within a single analytical framework among Indonesian adolescent girls. While many previous studies have examined only one or two determinants of anemia, this study simultaneously evaluated dietary patterns, sleep quality, physical activity, menstrual patterns, knowledge, and stress, thereby providing a broader understanding of factors potentially associated with anemia. Although no individual determinant reached statistical significance, these findings remain scientifically valuable because they strengthen the evidence supporting the multifactorial nature of anemia and demonstrate that negative findings are equally important for refining theoretical models and guiding future research. The scientific contribution of this study therefore extends beyond identifying significant or non-significant relationships; it provides empirical evidence supporting the WHO Comprehensive Framework for Action on Anaemia and highlights the need to incorporate biological indicators, nutritional assessments, and contextual determinants into future epidemiological studies.

The findings of this study have several important theoretical and practical implications. From a theoretical perspective, the results reinforce the WHO Comprehensive Framework for Action on Anaemia by demonstrating that anemia among adolescent girls should be understood as a multifactorial condition resulting from the interaction of biological, nutritional, behavioral, psychosocial, environmental, and health-system determinants rather than from isolated risk factors. The absence of statistically significant associations between the investigated variables and anemia does not invalidate existing theoretical models; instead, it highlights that these determinants are likely to operate through complex and interconnected pathways that may not be fully captured using individual behavioral indicators alone. Consequently, future theoretical models of adolescent anemia should integrate biological markers, nutritional assessments, reproductive health indicators, and contextual determinants to better explain the heterogeneous etiology of anemia across different populations.

From a practical perspective, the present findings suggest that anemia prevention programs should not rely exclusively on a single intervention, such as nutrition education or menstrual health promotion. Instead, comprehensive school-based strategies are needed to address the multiple pathways contributing to anemia. These strategies should include routine hemoglobin screening, monitoring of iron supplementation adherence, promotion of iron-rich diets with attention to iron bioavailability, menstrual health assessment, and continuous health education involving schools, families, and primary healthcare providers. In addition, strengthening collaboration between educational institutions and community health services may improve early detection and management of anemia among adolescents. These recommendations are consistent with the WHO Comprehensive Framework for Action on Anaemia and previous studies emphasizing that comprehensive nursing interventions integrating health promotion, nutritional improvement, and regular monitoring are essential for reducing the burden of anemia among Indonesian adolescent girls (Dewi et al., 2025).

This study also has several strengths that should be acknowledged. Unlike many previous studies that focused on only one or two determinants of anemia, the present study simultaneously evaluated dietary patterns, sleep quality, physical activity, menstrual patterns, knowledge about anemia, and stress within a single analytical framework. This comprehensive approach provides a broader understanding of the potential determinants of anemia among Indonesian adolescent girls and contributes empirical evidence supporting the multidimensional

nature of anemia. Furthermore, reporting non-significant findings is scientifically valuable because it reduces publication bias toward positive results and provides a more balanced understanding of the complexity of anemia etiology. These findings therefore contribute to refining current theoretical perspectives and identifying priorities for future nursing and public health research.

Nevertheless, several limitations should be considered when interpreting the findings. First, the cross-sectional design precludes causal inference because exposures and outcomes were measured simultaneously. Second, important determinants directly related to iron metabolism, including dietary iron intake, iron bioavailability, serum ferritin concentration, inflammatory conditions, adherence to iron supplementation, nutritional status, and socioeconomic factors, were not assessed and therefore could not be incorporated into the analytical model. Third, the relatively homogeneous distribution of several behavioral variables, particularly sleep quality and physical activity, may have reduced the statistical power to detect significant associations. These limitations suggest that the observed relationships should be interpreted cautiously and within the broader context of anemia as a multifactorial health problem.

Future studies are recommended to employ longitudinal or prospective study designs to clarify the causal relationships between biological, nutritional, behavioral, and psychosocial determinants and anemia among adolescent girls. In addition, future research should incorporate more comprehensive biological indicators, including serum ferritin, transferrin saturation, inflammatory biomarkers, dietary iron intake, and iron bioavailability, while also considering adherence to iron supplementation, household socioeconomic conditions, food security, and access to adolescent health services. Such multidimensional investigations are expected to provide more robust evidence for developing targeted nursing interventions and evidence-based public health policies aimed at reducing the burden of anemia among adolescent girls in Indonesia and other low- and middle-income countries.

Overall, the present study demonstrates that dietary patterns, menstrual patterns, sleep quality, physical activity, knowledge about anemia, and stress were not independently associated with anemia among adolescent girls in the study population. Rather than contradicting previous evidence, these findings reinforce the understanding that anemia is a multifactorial condition arising from the interaction of numerous biological, nutritional, behavioral, psychosocial, and environmental determinants. Therefore, effective anemia

prevention requires comprehensive and integrated strategies rather than interventions targeting individual risk factors alone. The findings of this study contribute to strengthening the current evidence base on adolescent anemia, support the multidimensional perspective proposed by the WHO Comprehensive Framework for Action on Anaemia, and provide important directions for future nursing research, clinical practice, and public health interventions.

Conclusion

This study found that dietary patterns, sleep quality, physical activity, menstrual patterns, knowledge about anemia, and stress levels were not significantly associated with anemia among adolescent girls. These findings suggest that anemia among adolescent girls is a multifactorial condition that cannot be explained by a single behavioral, biological, or psychosocial factor. The absence of significant associations indicates that other determinants, which were not examined in this study, may play a greater role in the occurrence of anemia. Overall, this study highlights the complexity of anemia among adolescent girls and emphasizes the need for a comprehensive approach when investigating its determinants.

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