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Impact of Dietary Patterns on Anemia Incidence in Adolescent Girls

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ABSTRACT Anemia remains a major public health concern among adolescent girls, as it impairs growth, cognitive performance, physical endurance, and overall well-being. In Magetan Regency, anemia prevalence remains high, reaching 51.02% in the Tebon Health Center area. Dietary inadequacy is recognized as one of the primary contributors to anemia during adolescence, a period characterized by rapid growth and increased nutritional demands. This study aimed to analyze the influence of dietary patterns on anemia incidence among adolescent girls at SMP Negeri 1 Barat, Magetan Regency. A cross-sectional observational design was employed, involving 122 female students aged 12–15 years selected through total sampling. Dietary patterns were measured using a validated questionnaire, and hemoglobin levels were assessed using a digital Hb device. Data were analyzed through univariate statistics and the Chi-square test with a significance level of $\alpha = 0.05$. The findings indicated that 55.7% of respondents exhibited poor dietary patterns, while 56.6% experienced mild anemia and 12.3% moderate anemia. Among students with good dietary habits, 75% did not experience anemia; conversely, 73.6% of those with poor dietary patterns had mild anemia. Statistical testing demonstrated a significant relationship between dietary patterns and anemia incidence ($p = 0.000$). These results confirm that inadequate dietary intake substantially contributes to reduced hemoglobin levels among adolescent girls. Strengthening nutrition education, promoting balanced meals, and enhancing school-based health programs are essential strategies for anemia prevention. Collaboration between health authorities, schools, and youth counseling groups is recommended to improve dietary behaviors and reduce anemia among adolescents.

INDEX TERMS Dietary Patterns, Anemia, Adolescent Girls, Hemoglobin, Nutritional Status.

I. INTRODUCTION

Anemia remains one of the most prevalent nutritional problems affecting adolescent girls worldwide, posing serious risks to physical growth, cognitive development, academic performance, and future reproductive health [1], [2]. The World Health Organization (WHO) reports that anemia continues to affect more than one-third of adolescent girls globally, with iron deficiency identified as the leading etiology [3]. In Indonesia, anemia among adolescents remains a persistent challenge, exacerbated by rapid growth during puberty, inadequate dietary intake, menstrual blood loss, and unhealthy eating behaviors [4], [5]. Recent surveillance data show that anemia prevalence in Magetan Regency reached 39% and was highest in the Tebon Health Center area at 51.02%, underscoring the urgent need for targeted local interventions [6].

State-of-the-art approaches for anemia prevention among adolescents include iron–folic acid supplementation, school-based nutrition education, improvement of dietary diversity, and community-based behavior-change interventions [7]–[10]. Advances in public health nutrition have emphasized the role of dietary patterns rather than individual nutrients, recognizing that overall food choices, meal frequency, and consumption of iron-rich and iron-enhancing foods significantly influence hemoglobin status [11]–[13]. Studies conducted in various low- and middle-income countries increasingly highlight that unhealthy dietary behaviors—such as skipping breakfast, excessive consumption of processed foods, low intake of fruits and vegetables, and limited consumption of animal-source foods—are strongly associated with anemia risk [14]–[16]. Furthermore, behavioral and psychosocial factors such as body-image concerns, peer influence, and food insecurity contribute to poor dietary habits among adolescents [17]–[19].

Despite extensive literature on anemia among adolescents, a research gap remains in understanding how dietary patterns specifically influence anemia incidence in rural Indonesian populations. Existing studies predominantly focus on urban settings, supplementation programs, or single-nutrient deficiencies, with limited investigation into comprehensive dietary behaviors among young females in rural public schools [20], [21]. Additionally, few studies integrate validated dietary assessments with objective hemoglobin measurement to examine this relationship in a school setting [22].

To address these gaps, this study aims to analyze the impact of dietary patterns on the incidence of anemia among adolescent girls at SMP Negeri 1 Barat, Magetan Regency. Understanding this relationship is critical for informing school-based nutrition policies and strengthening

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community-level anemia prevention programs. The contributions of this study are threefold:

1. It provides empirical evidence on the association between dietary patterns and anemia among adolescent girls in a rural Indonesian context, a population underrepresented in existing research.
2. It utilizes validated dietary and hemoglobin assessment methods to ensure reliable measurement of both exposure and outcome variables.
3. It offers practical recommendations for school health units, local health authorities, and policymakers to enhance preventive strategies targeting adolescent nutrition.

The remainder of this article is structured as follows: Section II describes the research methods, including study design, sampling, instruments, and analytical procedures. Section III presents the findings on dietary patterns and anemia incidence. Section IV discusses the results in relation to current evidence, identifies implications for public health practice, and outlines study limitations. Finally, Section V provides the conclusion and recommendations for future research.

II. METHODS

This study employed an observational analytic design with a cross-sectional approach to assess the relationship between dietary patterns and anemia incidence among adolescent girls. The methodological framework was constructed to ensure full replicability by specifying sampling procedures, inclusion and exclusion criteria, research instruments, measurement protocols, and analytical methods used throughout the study.

A. STUDY DESIGN AND SETTING

The study was conducted at SMP Negeri 1 Barat, located in the working area of Tebon Public Health Center (Puskesmas Tebon), Magetan Regency, East Java, Indonesia. Data collection was carried out between February and April 2025. The selection of this location was based on the high reported prevalence of anemia among adolescent girls in the district. The cross-sectional design enabled simultaneous measurements of dietary patterns and hemoglobin status, a recommended approach for identifying associations between behavioral and physiological variables in adolescent populations [26], [27].

B. STUDY POPULATION AND SAMPLE

The target population comprised all seventh-grade female students aged 12–15 years enrolled at SMP Negeri 1 Barat in the 2025 academic year. Total population sampling was used to recruit all eligible respondents, yielding a final sample size of 122 participants. The total sampling method was selected to reduce sampling error and ensure representation of the entire population group.

Inclusion Criteria

1. Female adolescents aged 12–15 years.
2. Enrolled in grade VII at SMP Negeri 1 Barat.
3. Not diagnosed with chronic diseases affecting iron metabolism (e.g., thalassemia, chronic kidney disease).
4. Willing to undergo hemoglobin testing and complete the dietary questionnaire.
5. Provided informed consent from parents or guardians.

Exclusion Criteria

1. Students absent during data collection.
2. Incomplete questionnaire responses.
3. Known pregnancy or medical conditions that impair hemoglobin interpretation.
4. Current use of medication affecting red blood cell production.

The application of strict eligibility criteria ensured homogeneity of the population and minimized confounders, consistent with best practices for cross-sectional nutritional epidemiology research [28].

C. VARIABLES AND OPERATIONAL DEFINITIONS

Independent Variable

Dietary Pattern – defined as habitual food consumption behavior measured through a structured self-administered questionnaire. The instrument assessed meal frequency, dietary diversity, intake of iron-rich foods, consumption of inhibitors and enhancers of iron absorption, and snacking behaviors. Scores were categorized into:

1. Good
2. Sufficient
3. Poor

Dependent Variable

Anemia Status – determined based on hemoglobin concentration measured via digital hemoglobinometer. Classification followed WHO cutoffs for adolescent girls:

1. Normal: ≥ 12 g/dL
2. Mild Anemia: 11–11.9 g/dL
3. Moderate Anemia 8–10.9 g/dL

This standardized classification is widely adopted in adolescent anemia surveillance [29].

D. INSTRUMENTS AND MEASUREMENT PROCEDURES

1. Dietary Pattern Questionnaire

The dietary pattern questionnaire consisted of 25 items developed based on established dietary assessment frameworks for adolescents and validated through expert review. A pilot test involving 15 students from another school yielded:

a. Validity coefficient (r-count ≥ 0.514)
b. Reliability coefficient (Cronbach's Alpha = 0.966)

These values indicate high internal consistency and appropriateness for field research [30].

2. Hemoglobin Measurement

Hemoglobin levels were assessed using a portable digital Hb analyzer (Hemocue type or equivalent). The device was calibrated daily according to manufacturer guidelines. Capillary blood was collected via finger-prick using sterile lancets. Each measurement followed a standardized protocol:

a. Participant seated for at least 10 minutes.
b. Index finger cleaned with 70% alcohol.
c. First blood drop wiped; second drop used for sampling.
d. Hemoglobin value digitally recorded.

This method is widely validated for community-based anemia screening [31].

E. DATA COLLECTION PROCEDURE

Data collection followed these steps:

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1. Coordination with school management and Puskesmas Tebon.
2. Distribution of informed consent letters to parents.
3. Administration of dietary questionnaires in classroom settings.
4. Individual hemoglobin testing conducted in the school's UKS (school health unit).
5. Verification of questionnaire completeness and data coding.

All data collectors were trained health personnel to ensure uniform procedures and reduce measurement bias.

F. DATA ANALYSIS

Data were processed using SPSS version 25. The analysis consisted of:

1. Univariate Analysis

a. Used to summarize frequencies and percentages for:
b. Dietary patterns
c. Anemia categories

2. Bivariate Analysis

Chi-square (χ^2) test was used to examine the association between dietary patterns and anemia status, employing a significance level of $\alpha = 0.05$. The Chi-square test is appropriate for categorical variables and is commonly used in nutritional epidemiology to assess relationships between diet and health outcomes [32]. Effect estimates were interpreted based on p-values and distribution patterns across contingency tables.

G. ETHICAL CONSIDERATIONS

This research was approved by the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya (Approval No. EA/3137/KEPK-Poltekkes_Sby/V/2025). Participation was voluntary, and confidentiality of all respondents was maintained. Hemoglobin results were privately communicated, and anemic students were referred to the school health unit for follow-up.

III. RESULTS

State Junior High School 1 Barat is one of the junior high schools located in the West District, Magetan Regency, East Java Province. Karangmojo District was expanded into West District and Kartoharjo District in 2000, after which West District was formed as a regional expansion of Karangmojo District. The capital of Magetan Regency, located in the northeast, is about 19 kilometers from West District. In addition to being equipped with classrooms and teachers' rooms, SMPN 1 Barat also has language laboratories, science, computers, student council rooms, sports, prayer rooms, and UKS. Data on the number of residents of SMP Negeri 1 West, the Administration section is 13 employees, 48 teachers, 781 students consisting of 373 male students, and 417 female students.

A. Characteristics of Female Adolescent Students at SMP Negeri 1 Barat

FIGURE 1 presents the age characteristics of female adolescent students at SMP Negeri 1 Barat, showing that the majority of respondents were 13 years old (73.8%), followed by those aged 12 years (23.7%), while only a small proportion were 14 years old (2.5%). This distribution indicates that early adolescence, particularly at age 13, represents the predominant demographic within the study population, reflecting a developmental stage marked by rapid growth and increased nutritional requirements.

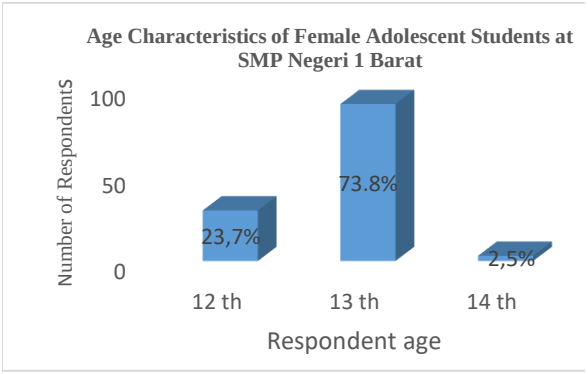

FIGURE 1. Age Characteristics of Female Adolescent Students at SMP Negeri 1 Barat

B. Eating Patterns and Anemia of Female Adolescent Students at SMP Negeri 1 Barat

TABLE 1
Frequency Distribution of Eating Patterns of Female Adolescent Students at SMP Negeri 1 Barat in 2025

Variable		N	%
Dietary habit	Good	12	9.8
	Sufficient	42	34.4
	Poor	68	55.7

Table 1 Lists the eating habits of students of SMP Negeri 1 Barat who participated in this study.This indicates that only a small proportion of the students in this study had good eating habits (9.8%), specifically 12 students, while the majority (55.7%), or 68 students, had poor dietary patterns.

TABLE 2
Frequency Distribution of Anemia Incidence Among Female Adolescent Students at SMP Negeri 1 Barat in 2025

Variable		N	%
Anemia	No Anemia	38	31.1
	Mild Anemia	69	56.6
	Moderate Anemia	15	12.3

TABLE 2 presents the distribution of dietary patterns among female adolescent students at SMP Negeri 1 Barat. The results show that a majority of respondents (55.7%) exhibited poor dietary patterns, while the remaining 44.3% demonstrated good dietary habits. This distribution indicates that more than half of the adolescents have not met recommended nutritional practices, suggesting limited intake of iron-rich foods and a tendency to consume low-nutrient snacks. Such conditions may contribute to increased vulnerability to anemia and highlight the need for targeted nutritional interventions within the school environment.

C. Analysis of The Impact of Dietary Patterns on The Incidence of Anemia in Female Adolescent Students at SMP Negeri 1 Barat

The following is a crosstab research table showing the relationship between dietary patterns and the prevalence of anemia among female adolescents at SMP Negeri 1 Barat:

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TABLE 3
Analysis of the Impact of Dietary Patterns on the Incidence of Anemia in Female Adolescent Students at SMP Negeri 1 Barat in 2025

		Anemia						Total		P-value
		Not		Mild		Moderat				
		N	%	N	%	N	%	N	%	
Dietary habit	good	9	75	3	25	0	0	12	100	0.000
	Suffi-cient	20	47.6	16	38.1	6	14.3	42	100	
	poor	9	13.2	50	73.6	9	13.2	68	100	
Total		38	31.1	69	56.6	15	12.3	122	100	

TABLE 4
Chi-Square statistics the Impact of Dietary Patterns On The Incidence Of Anemia In Adolescent Girls At SMP Negeri 1 Barat In 2025

Chi-Square Tests	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	27.839[a]	4	.000
Likelihood Ratio	29.219	4	.000
Linear-by-Linear Association	17.516	1	.000
N of Valid Cases	122		

TABLE 3 shows that students with appropriate dietary patterns were less likely to suffer from anemia (47.6%), while those with good dietary patterns were even less likely to experience anemia (75%). In contrast, students with moderately poor dietary patterns were more likely to suffer from mild anemia (73.6%). The analysis of the relationship between the two variables indicates that dietary patterns have a significant Impact on the incidence of anemia ((p = 0.000; α = 0.05).

TABLE 4 illustrated that based on the results of the Chi-Square statistical test as shown in table 4, the significance value of the test is p = 0.000, which is smaller than the error level α < 0.05. In conclusion, at a 95% confidence level, there is a significant The Impact Of Dietary Patterns On The Incidence Of Anemia In Adolescent Girls At SMP Negeri 1 Barat.

IV. DISCUSSION

A. RESPONDENT CHARACTERISTICS

Based on research conducted at SMP Negeri 1 Barat in Magetan Regency, the study participants were female adolescents aged 12 to 14 years, with the majority being 13 years old. This finding aligns with[11], who also reported that most seventh-grade girls at SMP Al-Basyariah in Rawa Panjang village were within the same age range. Adolescence is a transitional period marked by physical, emotional, and mental changes, making adolescents particularly vulnerable to various challenges. Issues such as unintended pregnancies, early marriage, and reproductive health problems frequently affect this age group. One such common issue is iron-deficiency anemia, particularly among adolescent girls[12]

Adolescence is a crucial stage of development leading toward adulthood. It bridges the gap between childhood and maturity, encompassing significant physical, psychological, and behavioral changes[13]. During this period, teenagers often begin to adopt new lifestyles and eating habits, Impacted by the demands of their changing bodies. Special attention must be given to their dietary needs, as rapid growth during this phase requires a higher intake of both energy and nutrients [8]

This phase is also a time of self-discovery, during which adolescents are highly Impacted by their environment. They often face social challenges, including low self-esteem, identity issues, social isolation, and anxiety—particularly around how they are perceived by others. Body image, or how one views their own physical appearance in terms of weight, shape, and societal standards, plays a major role in adolescent behavior. Due to social pressure surrounding body image, some teens intentionally restrict their food intake—sometimes going an entire day or more without eating. This behavior can lead to food insecurity and nutritional deficiencies, posing serious risks to their health, including the development of anemia [14].Researchers believe that the social environment, especially peer Impact, has a strong impact on how adolescents perceive and respond to their own body image. Based on both data and theory, it can be concluded that when adolescents identify someone or a group as having an "ideal" body, those with negative body image may strive to emulate them—often by reducing food intake. This pursuit of an ideal body can unknowingly reduce nutritional adequacy, and if such behavior persists over time, it can lead to nutrient deficiencies and increase the risk of conditions like anemia[15]

B. DIETARY PATTERNS AMONG FEMALE ADOLESCENTS

The findings of this study conducted at SMP Negeri 1 Barat in Magetan Regency revealed that most of the female students involved had poor dietary habits. An individual's eating behavior plays a significant role in their nutritional health. A healthy diet should include energy-giving, body-building, and regulatory foods, as these nutrients are essential for physical growth, brain development, body maintenance, and sustaining productivity, provided they are consumed in adequate amounts [16].

These findings are supported by research, which found that the majority of elementary students at LPQ Nurul Hikmah Candisari in Semarang also had unhealthy eating habits. However, this contrasts with the study, conducted in January 2024 at SMA Bunda Mulia, West Jakarta, where most tenth-grade students aged 14 to 16 were found to have healthy eating patterns. These differences may be attributed to the varying characteristics of each study. Economic conditions, which vary by region, can Impact one's ability to purchase or access nutritious food. In addition, respondent characteristics such as gender, age range, body image, and levels of physical activity may also affect dietary behavior and study outcomes [17].

Maintaining good nutritional and health status is possible through the consistent practice of a safe and balanced diet.

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An unbalanced diet in adolescence can lead to anemia, often caused by deficiencies in iron, protein, and vitamins. Overconsumption of foods that inhibit iron absorption—such as rice high in phytic acid and eggs—can reduce the body's ability to utilize iron effectively. This is considered part of an unhealthy diet. Furthermore, a lack of iron-rich foods—whether from animal sources like meat and fish or plant sources like leafy greens and legumes—can also lead to iron deficiency and eventually anemia[18]

Numerous studies have shown that adolescents with poor dietary habits are more prone to anemia. In addition to poor diet, non-compliance with prescribed iron supplementation also contributes to the problem. Therefore, it is crucial for adolescents to follow iron supplement guidelines and maintain a balanced diet to prevent anemia [19]. Based on the study findings and supporting theories, researchers believe that poor nutritional practices are widespread among adolescents. Many are aware of the importance of a balanced diet, yet fail to implement it in daily life. Instead, they tend to prefer foods of uncertain nutritional value, such as fast food. Adolescents often follow food trends without considering their nutritional content—for example, popular items like sebelak, sausages, or sweet beverages. This pattern of consumption highlights a growing concern about the disconnect between knowledge and practice regarding nutrition among teenagers.

C. THE IMPACT OF DIATERY PATTERNS ON THE INCIDENCE OF ANEMIA

The present study demonstrated a significant association between dietary patterns and anemia incidence among adolescent girls ($p = 0.000$). Students with good dietary patterns were far less likely to experience anemia (75% non-anemic), whereas those with poor dietary habits showed a substantially higher proportion of mild anemia (73.6%). These findings strongly support the conclusion that nutritional behavior plays a pivotal role in hemoglobin status during adolescence.

This relationship aligns with previous research conducted in various settings. A study by Khanal et al. [31] showed that adolescents with inadequate dietary intake were significantly more likely to develop anemia, even when receiving iron supplementation. Similarly, Paramastri et al. [26] demonstrated that dietary diversity and regular consumption of animal-source foods serve as protective factors against anemia. These parallels reinforce the consistency of the present study's findings with broader evidence.

However, some studies report different patterns. For instance, research conducted in higher socioeconomic regions found fewer cases of anemia despite moderate dietary inadequacies, suggesting additional protective factors such as fortified food access or better healthcare utilization [34]. This contrast emphasizes the contextual influence of environment and socioeconomic status on nutritional outcomes.

Limitations of the Present Study

Several limitations should be acknowledged to contextualize the findings:

1. **Single-Site Sampling**: The study focused solely on one junior high school, limiting generalizability to broader populations with diverse socioeconomic or cultural backgrounds.
2. **Self-Reported Dietary Data**: Dietary patterns were assessed through self-administered questionnaires, which are prone to recall bias and underreporting, similar to limitations highlighted by Brown and Larson [30].
3. **Confounding Variables Not Measured**: Factors such as menstrual history, parasitic infections, physical activity levels, psychosocial stress, and iron supplementation adherence were not assessed, although these are known to influence anemia risk [35].
4. **Cross-Sectional Design**: The design restricts causal inference; longitudinal studies could better capture temporal relationships between dietary behaviors and anemia development.
5. **Biomarker Limitations**: Hemoglobin alone cannot differentiate iron-deficiency anemia from other etiologies; additional biomarkers such as ferritin or transferrin saturation were not assessed, due to logistical constraints.

Despite these limitations, the findings remain robust due to validated instruments, trained data collectors, and strict eligibility criteria.

Implications of Findings

The results have several important implications:

1. **Strengthening School-Based Nutrition Education**: Schools are strategic settings for delivering targeted nutrition programs to adolescents. Interventions should include interactive learning strategies, food demonstrations, and counseling sessions.
2. **Enhancing Collaboration with Local Health Agencies**: Partnerships with Puskesmas and community health volunteers can support weekly iron supplementation, dietary counseling, and early detection of anemia.
3. **Improving Dietary Environments**: Schools could regulate the sale of nutrient-poor snacks and encourage provision of iron-rich foods during school activities.
4. **Promoting Parental Engagement**: Parents play a significant role in shaping home food environments. Awareness programs should empower parents to prepare balanced meals and limit processed food consumption.
5. **Future Research Directions**: Longitudinal studies incorporating additional biomarkers and assessing multiple lifestyle factors are recommended to develop a comprehensive model of anemia determinants among adolescents.

V. CONCLUSION

This study aimed to determine the impact of dietary patterns on the incidence of anemia among adolescent girls at SMP Negeri 1 Barat, Magetan Regency, a population identified as having a high prevalence of anemia. The findings demonstrated that dietary behavior plays a significant role in influencing hemoglobin status. Of the 122 participants assessed, 55.7% exhibited poor dietary patterns, while 56.6% were classified as having mild anemia and 12.3% moderate anemia. Statistical analysis using the Chi-square test

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confirmed a significant association between dietary patterns and anemia incidence ($p = 0.000$), indicating that adolescents with inadequate dietary intake were considerably more likely to develop anemia. Specifically, 75% of students with good dietary habits maintained normal hemoglobin levels, whereas 73.6% of those with poor dietary patterns experienced mild anemia. These results highlight the essential role of balanced nutrition—particularly adequate consumption of iron-rich foods and reduction of inhibitors of iron absorption—in maintaining optimal hematologic health among adolescent girls. Given the vulnerability of this age group due to menstrual blood loss and increased physiological demands, the study underscores the need for comprehensive, school-based health education programs focusing on dietary improvement. Additionally, collaboration between schools, local health centers, and community stakeholders is needed to strengthen iron supplementation initiatives, promote healthier eating environments, and encourage parental involvement in supporting adolescent nutrition. Future research is recommended to expand the study population across multiple schools, incorporate additional biomarkers such as ferritin to differentiate anemia etiologies, and evaluate the long-term effectiveness of nutritional interventions through longitudinal study designs. By addressing these gaps, future studies may contribute to developing a more robust framework for preventing anemia and improving adolescent health outcomes at regional and national levels.

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DATA AVAILABILITY

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTION

All authors contributed substantially to this study. Miliana Fantini led the data collection process and coordinated field activities. Nurlailis Saadah supervised the research design, methodology, and ethical approval process. Astuti Setiyani performed data analysis and interpretation of results. Sulikah contributed to the development of the manuscript, literature review, and critical revisions. All authors read and approved the final manuscript.

DECLARATIONS

ETHICAL APPROVAL

Approved by the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya (No. EA/3137/KEPK-Poltekkes_Sby/V/2025).

CONSENT FOR PUBLICATION PARTICIPANTS.

Written informed consent was obtained from all participants and their parents or legal guardians.

COMPETING INTERESTS

The authors declare no conflict of interest.

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