Coastal Lives, Nutritional Struggles: Anemia and Poor Diet Quality among Adolescent Girls in Indonesia

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Abstract: *Objectives:* Adolescent girls living in coastal areas are nutritionally vulnerable due to limited access to diverse and nutrient-rich foods. This study aimed to provide an overview of the nutritional profile and potential vulnerability to anemia among adolescent girls in this area.

Methods: A descriptive cross-sectional study was conducted in January 2025 among 159 adolescent girls aged 11-18 years in the coastal area of Galesong Selatan, Takalar Regency, Indonesia. Data on hemoglobin levels and dietary intake were collected using Hemocue 301 and two non-consecutive 24-hour recalls. Diet quality was assessed using the Diet Quality Index for Adolescents (DQI-A) adapted to Indonesian guidelines, and all data were analyzed descriptively.

Results: The prevalence of anemia among adolescent girls was 42.8%, with 23.9% classified as mild and 18.9% as moderate anemia. The median DQI-A score was 40.33, with subcomponent scores of DQ: 5.95, DD: 71.43, and DE: 40.14, indicating overall poor diet quality. Most participants had moderate dietary diversity (60.4%) and low dietary equilibrium, with 73.0% consuming less than half of the recommended daily nutrient intake (<50% RDA). The average intake of energy, protein, iron, folate, and vitamin C was markedly below the RDA, showing substantial nutrient inadequacy. Although weekend intake was slightly higher, nutrient levels remained insufficient to meet daily requirements.

Conclusions: Improving adolescent diet quality through balanced, micronutrient-rich food intake and adherence to iron-folic acid supplementation is essential not only to prevent anemia but also to strengthen vascular health and reduce future risks of congenital vascular anomalies. The findings can inform school-based nutrition education, local food optimization, and policy planning to support adolescent health in coastal communities.

Keywords: Adolescent; Female; Anemia; Diet; Residence Characteristics

INTRODUCTION

Anemia is one of the major global public health problems that significantly affects quality of life, particularly among vulnerable groups such as adolescent girls [1]. It is characterized by insufficient red blood cells or reduced oxygen-carrying capacity, with hemoglobin levels below 12.0 g/dL classified as anemia [2, 3]. Globally, anemia affects approximately one-third of the population, with a prevalence of 33.7% among women compared to 11.3% among men aged 15-49 years [4, 5]. In Indonesia, the 2023 Health Survey reported prevalence rates of 16.3% among individuals aged 5-14 years and 15.5% among those aged 15-24 years [6]. In Takalar Regency, South Sulawesi, the prevalence of anemia among adolescent girls in Galesong Subdistrict reached 65.1% [7], indicating an urgent local concern.

Anemia in adolescent girls commonly results from menstrual blood loss, inadequate nutrient intake, and poor dietary habits [8, 9]. Additional factors, such as prolonged menstruation, negative body image, food insecurity, intestinal infections, and undernutrition, further increase the risk [10, 11]. Beyond physiological and behavioral causes, anemia contributes to fatigue, reduced concentration, and impaired academic performance, which can negatively affect overall well-being and productivity [12].

Diet quality plays a crucial role in preventing anemia and other nutrition-related disorders. It reflects how well individual food consumption aligns with dietary recommendations, encompassing aspects of diversity, adequacy, and balance [13]. Limited access to nutritious foods and health services in coastal regions contributes to poor diet quality and nutritional vulnerability [14]. Agustina *et al.* (2020) emphasized that improving diet quality through regular meal patterns can reduce the risk of anemia among adolescent girls [15]. Recent studies also show that rural adolescents have poorer diet quality than urban peers due to limited nutrition literacy and food diversity [16]. Rural and coastal adolescents often exhibit poorer diet quality due to limited nutrition literacy and restricted food access [17, 18].

Despite its importance, there is still limited evidence on the use of the Diet Quality Index for Adolescents

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(DQI-A) to assess diet quality among adolescent girls in coastal Indonesian settings. Given the socioeconomic and environmental vulnerabilities of these communities, this study aimed to describe hemoglobin status and diet quality among teenage girls living in coastal areas of Takalar Regency, Indonesia, to provide a comprehensive understanding of their nutritional vulnerability.

METHODS

Study Design and Participants

This study employed a descriptive cross-sectional design and was conducted in January 2025 in the coastal area of Galesong Selatan, Takalar Regency, South Sulawesi, Indonesia. Two schools were purposively selected to ensure age and educational diversity, allowing for a wider age range and better representation of adolescents living in coastal areas of Takalar Regency. A total of 159 adolescent girls were recruited using a simple random sampling technique for the study. The inclusion criteria were teenage girls aged 11-18 years who were enrolled in one of the two selected local schools and were willing to participate in the study. The exclusion criteria included those who were ill at the time of data collection, had not yet experienced menarche or were menstruating during data collection, and those with a history of severe illness.

This study focused on describing the hemoglobin status and diet quality of adolescent girls in coastal areas; therefore, only descriptive statistical analysis was performed. No causal inference was intended, as the study aimed solely to provide a descriptive overview of hemoglobin status and diet quality.

Sample Size

The sample size was determined using Slovin's formula (Sevilla *et al*., 1992), which estimates the required sample size for a given population based on a specified precision level of 5%.

$$n = \frac{N}{1+N(e)^2} \rightarrow n = \frac{372}{1+372(0.05)^2} = \frac{372}{1.93} \approx 193$$

where n = required sample size, N = total population of interest, and e = margin of error. Based on the school population of N = 372 adolescent girls and *an error rate of* e = 0.05 (5%), the calculated minimum sample size was n = 193. Of these, 34 participants declined blood sampling, resulting in a final analyzed sample of 159 adolescent girls.

Data Collection Procedure

The data collected included respondents' characteristics, such as age, menarche status, consumption of iron and folic acid (IFA) supplements, and parental socioeconomic status, gathered through a structured questionnaire.

Hemoglobin concentration was measured using a HemoCue 301 device from capillary blood samples obtained via fingertip puncture by trained health personnel, following standard safety protocols.

Diet quality was assessed using two non-consecutive 24-hour dietary recalls, one conducted on a weekday and the other on a weekend day, through face-to-face interviews, with trained nutritionists. To minimize interviewer and recall bias, all interviewers received standardized training on 24-hour recall procedures, including the use of probing techniques and portion size estimation aids such as food models and household measures. Respondents were encouraged to recall all foods and beverages consumed within the previous day as accurately as possible.

The DQI-A, initially developed by Vyncke *et al.* (2013), has been adapted to align with the Indonesian Balanced Nutrition Guidelines (Pedoman Gizi Seimbang) issued by the Ministry of Health. This index has demonstrated good validity and reliability in assessing adolescent diet quality in various populations. The DQI-A consists of three main components: dietary quality (DQ), dietary diversity (DD), and dietary equilibrium (DE), where DE is calculated as the difference between dietary adequacy (DA) and dietary excess (DEx). The overall DQI-A score ranges from -33 percent to 100 percent, with higher scores indicating better overall diet quality. This index provides a comprehensive assessment of both the sufficiency and excesses in dietary intake, making it suitable for evaluating adolescent nutrition. Data were collected in January, which represents the typical dietary pattern period in this region and is not affected by significant seasonal variations in food availability.

Data Analysis

Dietary data were analyzed using NutriSurvey, Microsoft Excel, and IBM SPSS Statistics version 26. Diet Quality Index for Adolescents (DQI-A) scores were computed based on the adapted scoring described above. Categorical variables were presented as frequencies and percentages, while continuous

variables were summarized using mean, SD, median, minimum, and maximum values. Hemoglobin levels were analyzed both as constant data (g/dL) and as a categorical variable (anemia: Hb < 12.0 g/dL) through descriptive statistical analysis.

Ethical Considerations

This study received ethical approval from the Ethics Committee of the Faculty of Public Health, Universitas Hasanuddin (No. 099/UN4.14.1/TP.01.02/2025). Participation was voluntary, and informed consent was obtained from all respondents.

RESULTS

This study involved 159 adolescent girls living in a coastal area. The majority of respondents (66.0%) were in middle to late adolescence. Most participants experienced menarche at or after the average age (≥12 years), accounting for 79.9%. A larger proportion of respondents (66.0%) did not consume IFA supplements. Regarding parental education, the highest level attained by both fathers and mothers were senior high school or equivalent (44.6% and 41.5%, respectively). The most common occupation among fathers was farming or manual labor (56.0%), while the majority of mothers were housewives (89.3%). The majority of households (45.9%) reported a monthly income ranging from IDR 500,000 to IDR 1,000,000 (approximately USD 31.25-62.50), based on the exchange rate at the time of the study (Table **1**).

The mean hemoglobin concentration was 12.25 ± 1.31 g/dL, with 42.8% of adolescent girls classified as anemic (23.9% mild and 18.9% moderate) (Figure **1**). The prevalence of anemia was slightly higher among younger adolescents and those who did not consume IFA supplements, suggesting a potential influence of age and supplement adherence on hemoglobin status.

Based on the Diet Quality Index for Adolescents (DQI-A), the median total score was 40.33 (range 15.58-62.34), with 46.5% of respondents categorized as having poor diet quality (Figure **2**). The median DQ (Dietary Quality) score was 5.95, DD (Dietary Diversity) = 71.43, and DE (Dietary Equilibrium) = 40.14, indicating moderate diversity but low balance (Table **2**). Approximately 73.0% of respondents consumed less than half of the Recommended Dietary Allowances (RDA) for most nutrients, and only 3.8% achieved adequate intake (≥75% RDA) (Table **4**).

Patterns in dietary habits showed that vegetables, fruits, and plant-based proteins were the least consumed food groups, while oils and fried snacks were commonly consumed in excess (Figure **3**). Figure **4** shows that most food consumption came from the Low Nutrient group, consisting of high-energy, low-nutrient foods. The most frequently consumed items included instant noodles, sweetened breads, processed meats such as meatballs, sausages, and nuggets, as well as fried tofu and tempeh, deep-fried snacks, and margarine. These foods are typically high in energy but low in micronutrients and fiber.

The median Dietary Diversity (DD) score was 71.43 (range: 42.86-100), indicating a relatively good level of food variety. A detailed overview of dietary diversity among adolescent girls in the coastal area is presented in Table **3**.

The Dietary Equilibrium (DE) score was 40.14 (range: 6.92-79.78), reflecting a low level of dietary balance. DE was calculated by subtracting the Dietary Excess (DEx) score from the Dietary Adequacy (DA) score. Based on the results, all respondents had a DEx score of 0.00, indicating no excessive intake. A comprehensive description of dietary adequacy among coastal adolescent girls is shown in Table **4**.

The low median DQI-A score of 40.33 indicates that the diet quality of adolescent girls in coastal areas is still suboptimal, with 46.5% classified as having poor dietary patterns. Although dietary diversity (DD) is relatively adequate, the low scores for Dietary Quality (DQ) and Dietary Equilibrium (DE) suggest that food choices do not reflect balanced nutrition principles and are still dominated by energy-dense but nutrient-poor foods.

Figure **5** illustrates that the average nutrient intake of adolescent girls was below the Recommended Dietary Allowances (RDA) for most nutrients, both during weekdays and weekends. Energy, carbohydrate, and protein intakes were only around 50-65% of the recommendations, while micronutrient intake, particularly vitamin C, folic acid, and iron, was markedly insufficient, not exceeding 30% of the RDA. This pattern indicates an unbalanced dietary intake characterized by inadequate consumption of nutrient-dense foods such as fruits, vegetables, and animal-based sources of iron and folate.

Table 1: Respondent Characteristics

Respondent Characteristics	n (159)	%
Age (Years)		
Early Adolescence (11-13)	54	34.0
Middle to Late Adolescence (14-17)	105	66.0
Menarche		
Below average (<12 years)	32	20.1
At or above average (≥12 years)	127	79.9
IFA Supplement Consumption		
Yes	54	34.0
No	105	66.0
Father Education		
No education/never attended school	2	1.3
Did not complete elementary school	8	5.0
Completed elementary school	45	28.3
Completed junior high school	27	17.0
Completed senior high school	71	44.6
Diploma (D1/D3)	1	0.7
Bachelor's degree (D4/S1)	5	3.1
Mother Education		
No education/never attended school	2	1.3
Did not complete elementary school	6	3.8
Completed elementary school	41	25.8
Completed junior high school	36	22.6
Completed senior high school	66	41.5
Diploma (D1/D3)	1	0.6
Bachelor's degree (D4/S1)	7	4.4
Father Occupation		
Civil Servant/Military/Police	3	1.9
Farmer/Laborer	89	56.0
Fisherman	14	8.8
Private Sector Employee	7	4.4
Entrepreneur	44	27.7
Teacher	1	0.6
Doctor	1	0.6
Mother Occupation		
Civil Servant/Military/Police	3	1.9
Farmer/Laborer	1	0.6
Private Sector Employee	1	0.6
Entrepreneur	12	7.5
Housewife	142	89.3
Monthly Household Income (USD)		
$0 - $31.25	27	17.0
>$31.25 - $62.50	73	45.9
>$62.50 - $125.00	34	21.4
>$125.00 - $187.50	9	5.7
>$187.50 - $250.00	10	6.3
>$250.00	6	3.8

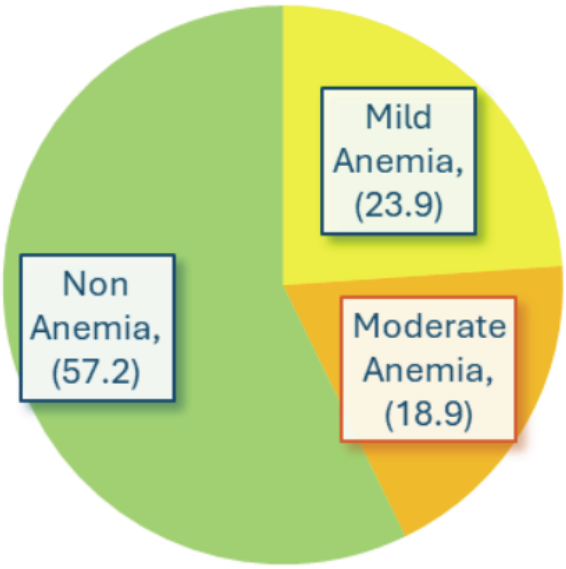

Figure 1: Distribution of anemia categories among adolescent girls.

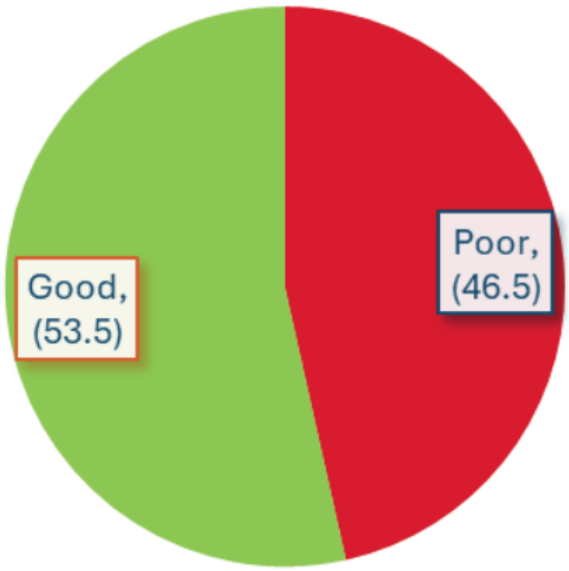

Figure 2: Distribution of adolescent diet quality.

Table 2: Distribution of Adolescent Diet Quality Based on DQI-A Components

DQI-A Components	Score Range	Median;Min-Max
Dietary Quality (DQ)	-100 - 100%	5.95;-24.28 to 19,48
Dietary Diversity (DD)	0 - 100	71.43;42.86 to 100.00
Dietary Equilibrium (DE)	0 - 100	40.14;6.92 to 79.78
Total DQI-A Score	-33 - 100	40.33;15.58 to 62.34

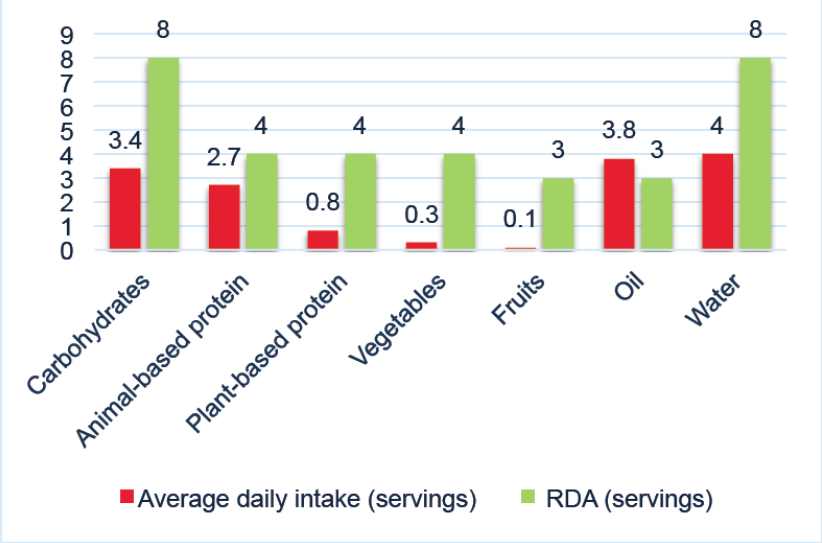

Figure 3: Comparison of average daily food group intake with recommended daily servings for a balanced diet among adolescent girls.

Overall, the findings highlight that adolescent girls in this coastal community experience both a high prevalence of anemia (42.8%) and suboptimal diet quality, characterized by inadequate micronutrient intake and limited dietary balance. The pattern suggests that low IFA consumption and limited dietary diversity may be contributing factors that warrant further intervention.

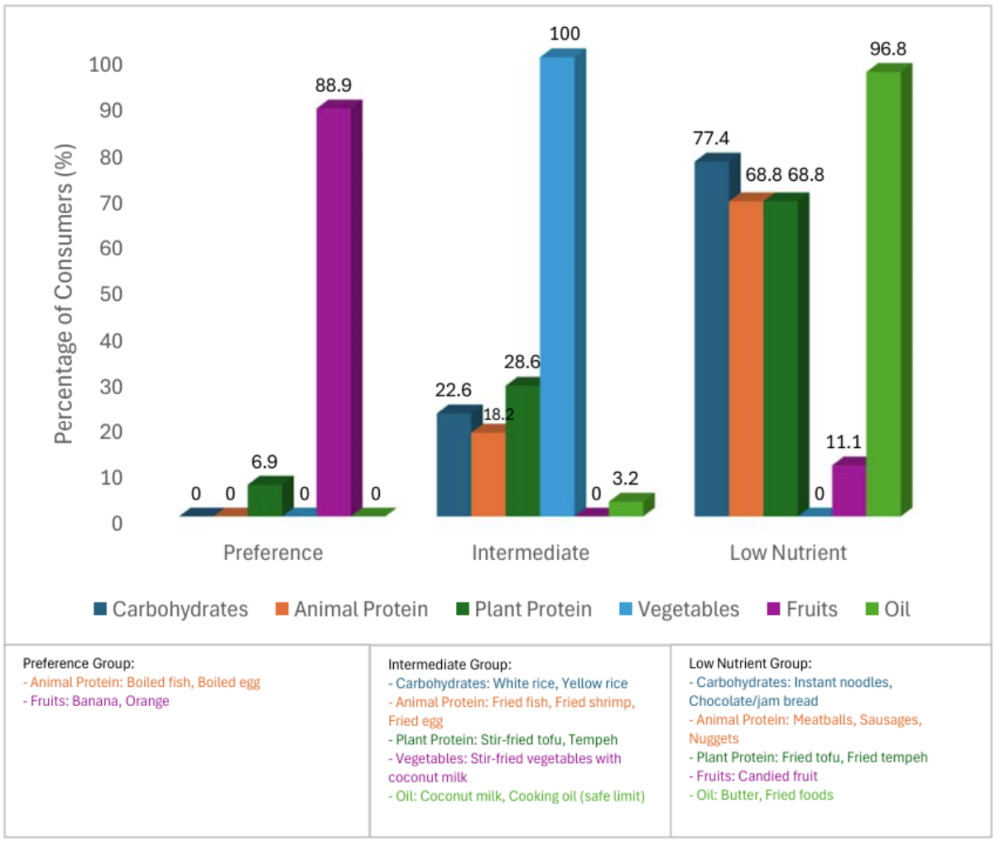

Figure 4: Percentage of food group consumption across preference, intermediate, and low-nutrient dietary patterns among adolescent girls.

Table 3: Distribution of Dietary Diversity Among Adolescent Girls Based on DQI-A Criteria

Dietary Diversity	n (159)	%
Not Diverse (0-3 groups)	3	1.9
Moderately Diverse (4-5 groups)	96	60.4
Diverse (6-7 groups)	60	37.7

Table 4: Distribution of Dietary Adequacy (Dietary Equilibrium Component) Among Adolescent Girls

Dietary Adequacy	n (159)	%
Inadequate (< 50% RDA)	116	73.0
Nearly Adequate (50% - 74% RDA)	37	23.3
Adequate (≥ 75% RDA)	6	3.8

DISCUSSION

The majority of respondents (66.0%) were in middle to late adolescence (ages 14-17), which aligns with the WHO definition of adolescence as individuals aged 10 to 19 years [19]. This period is a critical phase marked by various physiological and psychological changes, including sexual maturation. One of the key indicators in adolescent girls is menarche, which reflects the maturation of the reproductive system. This event not only marks biological maturity but also affects emotional and social aspects [20].

Most respondents (79.9%) experienced menarche at the age of 12 years or older. This is consistent with a study conducted among rural adolescent girls, which found that the majority experienced their first menstruation at the age of 12-14 years (76%), which is

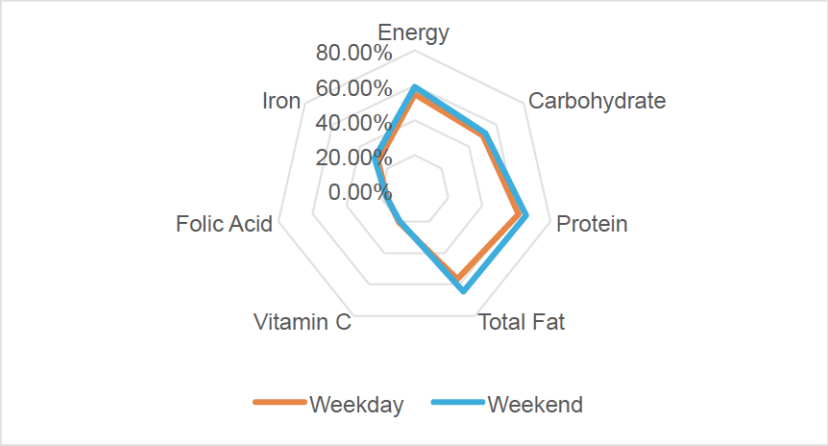

Figure 5: Comparison of the fulfillment of the Recommended Dietary Allowances (RDA) for certain nutrients between weekdays and weekends.

above the average age of menarche. Factors associated with early menarche among adolescent girls include nutritional status, the mother's age at menarche, energy intake, premenstrual syndrome, and residence [21]. Data from the 2023 Indonesian Health Survey (SKI) showed that the age of menarche among urban adolescents tends to be earlier than that of those in rural areas (73.8% vs. 68.5%) [6], indicating that the living environment also influences the timing of puberty.

Furthermore, 66.0% of adolescents in this study did not consume IFA supplements, despite IFA supplementation being one of the government's key strategies to prevent anemia among adolescents. This finding aligns with a study conducted in Makassar and Padang, two urban coastal areas, which reported that only 47% of adolescents consumed IFA regularly [22]. Such low compliance may increase the risk of anemia, as regular IFA intake has been shown to improve hemoglobin levels significantly.

The primary reasons adolescent girls did not consume IFA supplements were unwillingness or dislike, lack of knowledge about the benefits, forgetfulness or laziness, not receiving the supplements, unpleasant taste or smell, and parental restriction. Similar barriers were reported by Hidayanty *et al.* (2025), who found that unpleasant taste or smell, parental prohibition, forgetfulness, and misconceptions about menstruation were among the main reasons for poor adherence to IFA supplementation among Indonesian adolescents [22].

Most respondents' parents had a medium level of education, with 44.6% of fathers and 41.5% of mothers having completed senior high school or higher. This level is considered low when referring to higher education classifications, which begin at the tertiary level. Parental education plays a crucial role in shaping family health behaviors, including food choices, parenting practices, utilization of health services, and adoption of clean and healthy living habits at home. Educated parents also tend to choose more nutritious foods and educate their children more sustainably and consistently [23].

In terms of occupation, the majority of respondents' fathers were employed as farmers or laborers (56.0%), while most mothers were housewives (89.3%). The highest reported monthly family income ranged between 31.25 and 62.50 USD (45.9%), which is significantly below the 2025 Regional Minimum Wage (RMW) of Takalar Regency, set at 225.19 USD [24]. Parental occupation has a direct impact on household income, which in turn affects the family's ability to meet basic needs, including nutrition. The quality and quantity of adolescents' food intake are strongly influenced by socioeconomic conditions, particularly parental employment and income. While mothers play a central role in food preparation, the selection of food types remains dependent on the household budget [25].

The prevalence of anemia among adolescent girls in coastal areas was 42.8%, consisting of 23.9% with mild anemia and 18.9% with moderate anemia. According to the WHO classification (2008), a prevalence rate of ≥40% indicates that anemia is a severe public health problem [26]. This finding highlights that anemia remains a serious issue among adolescents in coastal and resource-limited settings, consistent with global data showing prevalence rates exceeding 40% in similar low- and middle-income contexts.

This finding is consistent with a 2022 study in Malaka Village, West Nusa Tenggara, Indonesia, which reported a 49.7% prevalence of anemia among adolescent girls [27]. Similarly, global evidence shows that anemia remains highly prevalent (>40%) among adolescent girls in low- and middle-income coastal regions, reflecting persistent nutritional vulnerabilities linked to limited dietary diversity and poor IFA adherence [28].

The occurrence of anemia among adolescents is generally attributed to inadequate intake of essential nutrients, particularly iron, protein, and vitamin C. In addition to dietary factors, social and environmental conditions also play a significant role in the development of anemia [29]. Beyond dietary intake, maternal micronutrient status during early life stages also influences vascular and hematologic health. Deficiencies in folate, iron, and vitamin A are known to impair placental and vascular development, potentially predisposing offspring to anemia and reduced oxygen transport capacity later in life [30, 31]. These micronutrient deficiencies may also affect endothelial function and angiogenic pathways, which are critical in early vascular development. Evidence suggests that such disturbances may contribute to the development of vascular anomalies, including congenital hemangiomas, highlighting the importance of adequate nutritional intake during adolescence and the preconception period as a preventive measure.A study found that adolescent girls living in rural areas have twice the risk of developing anemia compared to those in urban settings (OR = 2.06; 95% CI: 1.06-3.98), which may be attributed to limited access to nutritious food and essential health services [32].

The diet quality of adolescent girls in coastal areas was found to be poor, with 46.5% classified as having inadequate dietary patterns. This finding indicates that most adolescents are not yet able to meet the principles of balanced nutrition in their daily intake. This result is consistent with a study conducted in Depok, Indonesia, which used the Diet Quality Index for Adolescents (DQI-A) and found that among 108 students aged 16-18 years, the average diet quality score was 32.76, with 50% of respondents having poor diet quality [33]. While both current and previous studies highlight poor dietary quality among adolescents, Braune *et al.* (2025) emphasize that social interactions and perceived norms play an equally critical role in shaping food choices [34]. Low DQI-A scores in this study may be influenced by cultural dietary habits (such as reliance on rice and fried foods), limited availability of fresh fruits, vegetables, and animal-based proteins in coastal markets, and fluctuating food prices during certain seasons. These factors, coupled with low nutrition literacy, contribute to the dominance of energy-dense but nutrient-poor diets among adolescents.

Theoretically, diet quality is influenced by various factors, including nutritional knowledge, eating habits, social environment, and access to healthy foods. A systematic review found that Indonesian adolescents tend to have low intake of fruits, vegetables, and animal protein, along with high consumption of sodium, fast food, and sugar-sweetened beverages [35]. Global studies further support these findings, showing that the intake of fast food and sugary drinks significantly reduces diet quality scores among adolescents in Southeast Asia [36]. This condition reflects an imbalanced dietary pattern that may negatively impact nutritional status and long-term health.

Based on the total DQI-A scores, the overall diet quality of both adolescent groups falls into the low category, far from the maximum score of 100 that reflects good dietary quality [37]. This low score indicates inadequate intake of essential nutrients and an imbalanced food consumption pattern among adolescents. As shown in Figure **4**, the average nutrient intake of adolescent girls was below the Recommended Dietary Allowances (RDA) for most nutrients, both during weekdays and weekends. Energy, carbohydrate, and protein intakes reached only around 50-65% of the recommendations, while vitamin C, folic acid, and iron intake remained critically low (<30% of RDA). These findings suggest that anemia in this population is not only caused by low nutrient intake but also by poor absorption and low bioavailability due to unbalanced dietary patterns characterized by a predominance of refined carbohydrates and fried foods.

From a policy perspective, these results highlight the urgent need for integrated nutrition interventions targeting adolescent girls in coastal regions. Strengthening school-based nutrition education programs, ensuring regular distribution and monitoring of IFA supplements, and promoting local food-based approaches using affordable nutrient-rich sources, such as small fish, legumes, and green leafy vegetables, are essential. Partnerships between schools, public health centers, and community leaders could enhance awareness, improve IFA compliance, and promote healthier food environments for adolescents.

The coexistence of anemia and poor diet quality among adolescent girls in coastal areas indicates a serious nutritional vulnerability that, if left unaddressed, may progress toward chronic under nutrition and long-term health risks. The findings show that micronutrient intake, particularly vitamin C, folic acid, and iron, was markedly insufficient, not exceeding 30% of the RDA. In contrast, energy, carbohydrate, and protein intakes reached only about 50-65% of the recommended levels. This suggests that anemia in this population may not solely result from low intake but also from poor nutrient absorption due to dietary inadequacy and low bioavailability.

Similar observations were reported by Berhe *et al.* (2022), who noted that anemia among adolescent girls is strongly associated with insufficient dietary diversity and micronutrient intake, leading to impaired growth, cognitive function, and reproductive health outcomes later in life [10]. Furthermore, prolonged exposure to suboptimal diet quality and insufficient iron intake have been associated with a higher risk of chronic energy deficiency and undernutrition, potentially reinforcing intergenerational cycles of malnutrition [38]. Considering that adolescent girls represent future mothers, this condition underscores the urgent need for targeted interventions to prevent a double or even triple burden of malnutrition, where anemia coexists with undernutrition and poor dietary quality, before these risks extend into adulthood and future pregnancies.

LIMITATIONS

This study has several limitations. Dietary intake was self-reported using 24-hour recalls, which may introduce recall bias. Only hemoglobin was measured as a biochemical indicator, without supporting markers such as serum ferritin or folate levels to confirm iron status. Additionally, the cross-sectional design limits the ability to infer causality or observe changes over time, as longitudinal data were not collected.

CONCLUSIONS

This study reveals that anemia prevalence among adolescent girls in coastal areas reached 42.8%, reflecting a serious public health concern according to WHO standards. The median DQI-A score of 40.33 indicates low overall diet quality, with 46.5% of respondents categorized as having poor dietary patterns. Although dietary diversity (DD) was relatively adequate, dietary quality (DQ) and dietary equilibrium (DE) remained low, characterized by excessive consumption of energy-dense, nutrient-poor foods and insufficient intake of vegetables, fruits, and both animal- and plant-based proteins.

Beyond its relevance to anemia, these findings highlight that poor dietary quality and micronutrient deficiencies, particularly in iron, folate, and vitamin A, may impair vascular integrity and angiogenic processes during critical growth periods. Nutritional inadequacies during adolescence, if continued into preconception and pregnancy, could increase susceptibility to vascular anomalies such as congenital hemangiomas. Thus, improving adolescent nutrition represents not only a preventive strategy against anemia but also a foundation for long-term vascular and reproductive health.

Nutrition-sensitive interventions should therefore focus on strengthening adherence to iron-folic acid supplementation, promoting balanced and diverse diets, and optimizing the use of local, nutrient-rich food sources. Integrating dietary education, school-based nutrition programs, and community food initiatives may help reduce both anemia and the risk of micronutrient-related vascular abnormalities.

This study contributes new evidence by being among the first to apply the Diet Quality Index for Adolescents (DQI-A) in a coastal Indonesian population, providing a comprehensive assessment of adolescents' dietary balance, diversity, and adequacy within this unique context. The findings can guide policymakers and public health practitioners in designing context-specific interventions that integrate dietary education, iron-folic acid supplementation, and local food-based strategies to improve adolescent nutrition and reduce anemia prevalence.

Furthermore, the results underscore the importance of addressing dietary factors that may impact vascular development and long-term reproductive health. Future research should employ longitudinal designs and include broader biochemical indicators to clarify the causal pathways linking adolescent diet quality, vascular integrity, and the nutritional prevention of congenital vascular anomalies, such as hemangiomas.

REFERENCES

[1] World Health Organization. Nutritional anaemias: tools for effective prevention. Geneva: WHO 2017.

[2] Krishnan V, Zaki RA, Nahar AM, Jalaludin MY, MajidHA. The longitudinal relationship between nutritional status and anaemia among Malaysian adolescents. Lancet Reg Health West Pac 2021; 15: 100228.

https://doi.org/10.1016/j.lanwpc.2021.100228

[3] World Health Organization. Anaemia [Internet]. Geneva: WHO; 2020 [cited 2025 Nov 13]. Available from: https://www.who.int/news-ro om/fact-sheets/detail/anaemia

[4] Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. Ann N Y Acad Sci 2019; 1450: 15-31. https://doi.org/10.1111/nyas.14092

[5] Institute for Health Metrics and Evaluation (IHME). The Lancet: New study reveals global anemia cases remain persistently high among women and children; anemia rates decline for men. Seattle: IHME 2023.

[6] Ministry of Health of the Republic of Indonesia. Indonesian Health Survey (SKI) 2023 Report [Internet]. Jakarta: Health Development Policy Agency 2023 [cited 2025 Nov 13]. Available from: https://www.kemkes.go.id/resources/download/info-terkini/Laporan-SKI-2023.pdf

[7] Sanas NT. The effect of multiple micronutrient supplements and TikTok video education on increasing hemoglobin levels in adolescent girls [thesis]. Makassar: Hasanuddin University 2024.

[8] Deivita Y, Syafruddin S, Andi Nilawati U, Aminuddin A,Burhanuddin B, Zahir Z. Overview of anemia: risk factors and solution offering. Gac Sanit 2021; 35(Suppl 2): S235-41. https://doi.org/10.1016/j.gaceta.2021.07.034

[9] Fitria L, Puspita ID. Anemia is associated with dietary and sleep quality in Indonesian adolescent girls: a cross-sectional study. Al-Sihah Public Health Sci J 2020; 12: 136. https://doi.org/10.24252/al-sihah.v12i2.15443

[10] Weldegerima L, Kahsay A, Hadush H. Magnitude and associated factors of anemia among adolescent girls in Ethiopia: a systematic review and meta-analysis. Arch Public Health 2022; 80: 1-15. https://doi.org/10.1186/s13690-022-00942-y

[11] Sistiarani C, Wati E, Rahardjo S. Diet behavior and consumption of iron inhibitors: incidence of anemia in teenage girls. J Public Health Afr 2023; 14: 1-6. https://doi.org/10.4081/jphia.2023.2593

[12] Mumena WA, Alnezari AI, Safar HI, AlharbiNS, AlahmadiRB, QadhiRI. *et al*. Media use, dietary intake, and diet quality of adolescents in Saudi Arabia. Pediatr Res 2023; 94: 789-95. https://doi.org/10.1038/s41390-023-02505-5

[13] Mulyani I, Dieny FF, Rahadiyanti A, Fitranti D, Tsani AFA, Etisa Murbawani A.The effect of motivational interviewing and Instagram-based nutrition education classes on changes in healthy weight loss knowledge and diet quality of obese female students (in Indonesia). J Gizi Klin Indones 2020; 17: 53. https://doi.org/10.22146/ijcn.53042

[14] Suciyanti D, Kolopaking R, Mustafa A, Iwan S, Witjaksono F, Fahmida U. Effect of optimized food-based recommendations on nutrient intakes, hemoglobin levels, and memory performance of adolescent girls in East Java, Indonesia. Nutr J 2025; 24: 13. https://doi.org/10.1186/s12937-024-01061-w

[15] Agustina R, Nadiya K, El Andini A, Setianingsih AA, Sadariskar AA, Prafiantini E. *et al*. Associations of meal patterning, dietary quality and diversity with anemia and overweight-obesity among Indonesian schoolgoing adolescent girls in West Java. PLoS One 2020; 15: e0231519. https://doi.org/10.1371/journal.pone.0231519

[16] Dewi RS, Dwiriani CM, Khomsan A. Nutritional knowledge, diet quality and nutritional status of school-going adolescents in rural and urban areas in West Aceh. AcTion Aceh Nutr J 2024; 9: 297. https://doi.org/10.30867/action.v9i2.1723

[17] Muhammad A, Saleem S, Ahmad D, Tariq E, Shafiq Y. Gutka consumption and dietary partialities explaining anemia in women of a coastal slum of Karachi, Pakistan: a mixed-method study. PLoS One 2022; 17: e0276893. https://doi.org/10.1371/journal.pone.0276893

[18] Palimbong V, Karjoso TK, Damayanti R. The role of socio-cultural issues in anemia in adolescent girls on South Morotai Island in 2021 (in Indonesia). Hearty 2022; 11: 69. https://doi.org/10.32832/hearty.v11i1.7441

[19] World Health Organization. Health for the world's adolescents: a second chance in the second decade [Internet]. Geneva: WHO 2014 [cited 2025 Nov 13]. Available from: https://www.who.int/publications/i/item/WHO-FWC-MCA-14.05

[20] Mastorci F, Piaggi P, Bastiani L, Trivellini G, Cristina D, Casu A, *et al*. The impact of menarche on health-related quality of life in a sample of Italian adolescents: evidence from the school-based AVATAR project. Eur J Pediatr 2020; 179: 973-8. https://doi.org/10.1007/s00431-020-03594-8

[21] Lestari CT, Kustiyah L, Khomsan A. The energy intake, nutritional status, menarche age, and premenstrual syndrome in female adolescents. J Gizi Diet Indones 2024; 12: 273. https://doi.org/10.21927/ijnd.2024.12(4).273-283

[22] Hidayanty H, Nurzakiah N, Irmayanti I, Yuliana Y, Helmizar H, Yahya Y. Perceived barriers and enablers for taking iron-folic acid supplementation regularly among adolescent girls in Indonesia: a pilot study. Int J Environ Res Public Health 2025; 22: 1-17. https://doi.org/10.3390/ijerph22020209

[23] Kocaadam-Bozkurt B, Sözlü S, Macit-Çelebi MS. Exploring the understanding of how parenting influences children's nutritional status, physical activity, and BMI. Front Nutr 2023; 9: 1096182. https://doi.org/10.3389/fnut.2022.1096182

[24] Provincial Government of South Sulawesi. Governor's Decree of South Sulawesi No. 1423/XII/2024 on the determination of the 2025 Provincial Minimum Wage of South Sulawesi (in Indonesian). Makassar: Provincial Government of South Sulawesi 2024.

[25] Notoatmodjo S. Health promotion and health behavior (in Indonesian). Jakarta: Rineka Cipta 2012.

[26] World Health Organization. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia [Internet]. Geneva: WHO 2008 [cited 2025 Nov 13]. Available from: https://apps.who.int/iris/handle/10665/43894

[27] Hidayati BN, Salfarina AL, Ariyanti M. The correlation between menstruation patterns and adolescent anemia incidence in the coastal village of Malaka, 2022. J Nurs Res Publ Media 2023; 2: 1-9. https://doi.org/10.55887/nrpm.v2i1.29

[28] Kedir S, Abate KH, Mohammed B, Ademe BW. Weekly iron-folic acid supplementation and its impact on children and adolescents' iron status, mental health and school performance: a systematic review and meta-analysis in sub-Saharan Africa. BMJ Open 2024; 14: 1-10. https://doi.org/10.1136/bmjopen-2024-084033

[29] Yanti S, Sari YAP, Meilina A. Diet, protein, iron and vitamin C intake on anemia status of adolescent girls. J Appl Nurs Health 2024; 6: 177-83. https://doi.org/10.55018/janh.v6i1.192

[30] Souza SWD, Glazier JD. Homocysteine metabolism in pregnancy and developmental impacts. Nutrients 2022; 10: 1-14. https://doi.org/10.3389/fcell.2022.802285

[31] Ayoub G. Vitamins, vascular health and disease. Nutrients 2025; 9: 1-31. https://doi.org/10.3390/nu17182955

[32] Nadiyah N, Sitoayu L, Dewanti LP. Adolescent girls living in

rural Indonesia have twice the risk of being anemic. Gizi Indones 2022; 45: 35-46.
https://doi.org/10.36457/gizindo.v45i1.614

[33] Hidayat ZF, Marjan AQ, Wahyuningsih U. Diet quality index for adolescents' scores among 16-18-year-old adolescents. J Gizi Diet Indones 2025; 13: 132-9.
https://doi.org/10.21927/ijnd.2025.13(2).132-139

[34] Braune T, Kudlek L, Xiao C, Tang H, Demers-Potvin É, Harris HA. *et al*. Interpersonal determinants of diet quality and eating behaviors in people aged 13-30 years: a systematic scoping review. Obes Rev 2025; 26: 1-14.
https://doi.org/10.1111/obr.13835

[35] Rachmi CN, Jusril H, Ariawan I, Beal T, Sutrisna A. Eating behaviour of Indonesian adolescents: a systematic review of the literature. Public Health Nutr 2021; 24(Suppl 2): S84-97.
https://doi.org/10.1017/S1368980020002876

[36] Agustina R, Rianda D, Setiawan EA. Relationships of child-, parent-, and environment-associated determinants with diet quality, physical activity, and smoking habits among Indonesian urban adolescents. Food Nutr Bull 2022; 43: 44-55.
https://doi.org/10.1177/03795721211046145

[37] Vyncke K, Cruz Fernandez E, Fajó-Pascual M, Cuenca-García M, De Keyzer W, Gonzalez-Gross M. *et al*. Validation of the diet quality index for adolescents by comparison with biomarkers, nutrient and food intakes: the HELENA study. Br J Nutr 2013; 109: 2067-78.
https://doi.org/10.1017/S000711451200414X

[38] Parajuli J, Prangthip P. Adolescent nutrition and health: a critical period for nutritional intervention to prevent long-term health consequences. Nutr Health Res 2025; 1-14.
https://doi.org/10.1007/s13668-025-00706-4