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**Research Article**

# Food Provision Quality and Anemia Risk Among Female Adolescents in Islamic Boarding Schools: A Descriptive Mixed-Methods Study

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**Abstract**

***Background***: Anemia in adolescent girls remains an enduring public health concern, affecting populations across the world, with Indonesia being no exception. Female students living in Islamic boarding schools are particularly vulnerable because their daily food intake largely depends on institution-provided meals. ***Objective***: This study aimed to assess nutritional gaps in pesantren dietary patterns and identify food-related factors associated with anemia risk among adolescent girls. ***Methods***: A descriptive mixed-methods study was conducted in three Islamic boarding schools in Tasikmalaya, West Java, Indonesia. Seven-day menus were analyzed and compared with the 2019 Indonesian Recommended Dietary Allowances (RDA) for girls aged 13–18 years. In-depth interviews with kitchen managers and focus group discussions (FGDs) with female students were conducted, and qualitative data were analyzed thematically. ***Results***: The protein, iron, and vitamin C levels in all of the menus were less than 80% of the recommended dietary allowances. Iron and vitamin C were found to be the most important nutritional gaps linked to a higher risk of anemia. Qualitative findings revealed limited food budgets, the absence of nutrition professionals, and routine menu-planning practices. Although students generally perceived the meals as adequate, they reported limited variety and repetitive menus. ***Conclusions***: Food provision in the studied pesantren was insufficient to meet the nutritional needs of adolescent girls, particularly for iron and vitamin C. Strengthening nutrition-sensitive menu planning, involving nutrition professionals, and increasing the use of locally available nutrient-rich foods may help prevent anemia in Islamic boarding school settings.

***Keywords***: Adolescent; Food services; Iron deficiency anemia; Islamic boarding school; Nutritional status.

**جودة توفير الطعام وخطر فقر الدم بين المراهقات في المدارس الداخلية الإسلامية: دراسة وصفية بطرق مختلطة**

**الخلاصة**

**الخلفية**: لا يزال فقر الدم لدى الفتيات المراهقات مصدر قلق صحي عام مستمر، يؤثر على السكان في جميع أنحاء العالم، وليست إندونيسيا استثناء. الطالبات المقيمات في المدارس الداخلية الإسلامية معرضات بشكل خاص لأن تناولهن اليومي يعتمد بشكل كبير على الوجبات التي تقدمها المؤسسات. **الهدف**: تقييم الفجوات الغذائية في أنماط غذائية البيسانترين وتحديد العوامل الغذائية المرتبطة بخطر فقر الدم بين الفتيات المراهقات. **الطرائق**: أجريت دراسة وصفية بطرق مختلطة في ثلاث مدارس داخلية إسلامية في تاسيكمالايا، جاوة الغربية، إندونيسيا. تم تحليل قوائم الطعام لمدة سبعة أيام ومقارنتها مع الحصص الغذائية الموصى بها في إندونيسيا لعام 2019 للفتيات من عمر 13 إلى 18 سنة. أجريت مقابلات معمقة مع مديري المطابخ ومناقشات مجموعات تركيز مع طالبات، وتم تحليل البيانات النوعية بشكل موضوعي. **النتائج**: كانت مستويات البروتين والحديد وفيتامين سي في جميع القوائم أقل من 80٪ من الحصص الغذائية الموصى بها. وجد أن الحديد وفيتامين سي هما أهم الفجوات الغذائية المرتبطة بزيادة خطر فقر الدم. كشفت النتائج النوعية عن ميزانيات غذائية محدودة، وغياب متخصصي التغذية، وممارسات روتينية لتخطيط القوائم. على الرغم من أن الطلاب اعتبروا الوجبات بشكل عام كافية، إلا أنهم أبلغوا عن تنوع محدود وقوائم طعام متكررة. **الأستنتاجات**: كان توفير الطعام في البيسانترين غير كاف لتلبية الاحتياجات الغذائية للفتيات المراهقات، خصوصا للحديد وفيتامين سي. قد يساعد تعزيز تخطيط القوائم الحساسة للتغذية، وإشراك المتخصصين في التغذية، وزيادة استخدام الأطعمة الغنية بالعناصر الغذائية المحلية في الوقاية من فقر الدم في المدارس الداخلية الإسلامية.

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## INTRODUCTION

Adolescence is a crucial stage in human development, during which the body undergoes rapid physical growth and profound physiological changes, leading to a significant increase in the body's requirement for essential micronutrients [1]. Adolescent girls are essential to maintaining the quality and diversity of food, as nutritional needs increase substantially during puberty and menstruation [1]. Iron deficiency, often accompanied by inadequate intake of other key nutrients, remains a leading driver of anemia, which disproportionately burdens adolescent girls across the world [2,3]. Anemia remains a formidable public health burden, with its impact felt most acutely in low- and middle-income countries. The World Health Organization (WHO) said that in 2023, about 30.7% of women of childbearing age around the world had anemia. Southeast Asia always had one of the highest rates of the disease in the world [4]. In addition to dietary intake, several physiological factors contribute to anemia among adolescent girls, including accelerated growth during puberty and increased iron demands associated with menstruation [5,6]. Among

adolescent girls, iron deficiency anemia may impair cognitive performance, reduce academic achievement and physical work capacity, and weaken immune function, thereby affecting quality of life and long-term productivity [5,7]. In Indonesia, anemia among adolescent girls remains a persistent public health concern. According to the Indonesian Basic Health Research Report (Riskesdas) published between 2007 and 2018, anemia cases are still very common. From 2007 to 2018, the rate of anemia increased from 19.7% to 27.2% in women (≥ 15 years) and from 13.1% to 20.3% in men (≥ 15 years) [8]. Although weekly iron-folic acid supplementation has been a cornerstone of Indonesia's adolescent health policy, evidence across studies suggests that both program coverage and adherence remain suboptimal. At the same time, a food-based approach to preventing anemia receives relatively limited attention [9–13]. This gap is important because dietary adequacy constitutes a fundamental determinant of iron status, particularly among adolescents living in institutional settings where centralized meal provision systems largely determine food access. Islamic boarding schools (pesantren) represent a distinctive institutional food environment in Indonesia. By 2024, more than 36,000 registered pesantren accommodated millions of students (santri), many of whom are adolescent girls residing full-time within the institution [14]. In these settings, students rely entirely on institution-provided meals to meet their daily nutritional needs. Consequently, the quality of food provision directly influences students' nutritional adequacy and health outcomes. A study of 153 adolescents in boarding school showed that the quality of food remains inadequate [15]. The menu served is usually simple, lacking variety and repetitive [16]. Food service management in many boarding schools is generally carried out by personnel without formal nutrition training, menu planning based on customary practices, budget constraints, and the absence of nutrition guidelines [16,17]. Previous studies on anemia among adolescent girls in pesantren have primarily focused on individual-level factors, including hemoglobin levels, nutritional knowledge, dietary behavior, and adherence to iron supplementation programs. A literature review also identified inadequate iron intake, low vitamin C consumption, and poor dietary diversity as important contributors to anemia risk among female students in boarding school settings [18]. Nevertheless, existing evidence has paid limited attention to the institutional food environment that shapes students' daily dietary intake. In particular, studies examining the nutritional quality of institutional menus, kitchen management practices, and students' perceptions of meals provided in pesantren remain scarce. As a result, important structural determinants of anemia risk may be overlooked, potentially limiting the effectiveness and sustainability of interventions that rely mainly on supplementation and nutrition education. Recent evidence increasingly emphasizes the importance of food-based and institution-sensitive approaches in addressing adolescent anemia. Improving the quality of food nutrition in institutions by providing a balanced diet and increasing the intake of vitamin C-rich foods should be a priority, as these measures can enhance iron absorption and help prevent anemia in adolescent girls [19]. A systematic review reported that integrated interventions combining dietary modification, nutrition education, and iron supplementation were more effective at improving hemoglobin status than single interventions alone [20]. These findings point to institutional food provision as a critical upstream factor shaping nutritional outcomes among boarding school adolescents, warranting closer academic and policy attention. Therefore, this study examines the risk of anemia among adolescent girls through the lens of the institutional food supply system by assessing the nutritional quality of food provided in three Islamic boarding schools in Indonesia. It further explores kitchen management practices and students' perceptions of institutional food, providing a more comprehensive understanding of how the pesantren food environment affects nutritional adequacy and anemia risk. By integrating quantitative dietary analysis with qualitative investigations, this study is expected to provide evidence to better understand the risk of anemia from the perspective of the institutional food supply system, thereby supporting the development of nutrition-sensitive food management strategies in Islamic boarding schools and other similar institutions.

## METHODS

### *Study design and setting*

This study employed a descriptive mixed-methods design, integrating quantitative nutritional analysis with qualitative investigation, which could not be adequately explored with a single-method approach, among female adolescent residents of Islamic boarding schools. A mixed-methods approach was chosen to capture both the measurable nutritional adequacy of institutional meals and the contextual factors influencing food provision practices and meal acceptability, which could not be adequately explored with a single-method approach. The study was conducted at three Islamic boarding schools (pesantren) in Salopa, Rajapolah, and Manonjaya, Tasikmalaya, West Java, Indonesia. The institutions were purposively selected based on the following criteria: providing full-time residential accommodation for adolescent female students and implementing centrally managed meal services that provided three meals per day through institutional kitchens. Data collection was conducted between October and December 2025.

### *Data sources and collection*

The quantitative component assessed the provision of institutional food using the weekly menu for each pesantren, collected over seven consecutive days and including all meals provided, namely breakfast, lunch, dinner, and snacks, if available. Information on foodstuffs, cooking methods, and portion sizes was obtained through direct observation and review of

institutional menu records. The qualitative component explored food preparation practices and students' experiences with institutional food. In-depth interviews were conducted with one kitchen manager from each pesantren, using a semi-structured guide that covered menu planning, food procurement, budget allocation, the availability of nutritionally trained personnel, and challenges in providing nutritious food. The interviews were conducted individually, lasted approximately 30-45 minutes, and were audio-recorded with participants' consent. To capture students' perspectives, one focus group discussion (FGD) was conducted in each pesantren, involving six adolescent students (total n = 18). Participants were deliberately selected based on the following criteria: 13-18 years old, full-time residents of the pesantren for at least 6 months, and willing to participate. Participants for the qualitative component were selected using purposive sampling to ensure information-rich cases: one kitchen manager per pesantren (n = 3) with direct responsibility for menu planning, and six female students per pesantren (n = 18 total) meeting the eligibility criteria. This sample size was considered adequate to reach thematic saturation for a descriptive, institution-level qualitative inquiry of this scope. The discussion explored perceptions of food adequacy and variety, food preferences, food acceptance, eating practices, and consumption of foods obtained outside the institutional food system. Each FGD lasted 60-90 minutes and was recorded with participants' consent.

### *Ethical considerations*

Ethical approval for this study was obtained from the Health Research Ethics Commission, Faculty of Public Health, Diponegoro University (No. 320/EA/KEPK-FKM/2025). Institutional permission was also obtained from the management of each participating pesantren prior to data collection. All study procedures were conducted in accordance with research ethics principles, including voluntary participation, confidentiality, and anonymity. Written informed consent was obtained from all adult participants. For participants aged under 18 years, assent was obtained from the students, while permission was granted by the dormitory guardians acting as institutional representatives. Participants were informed of their right to withdraw from the study at any stage without penalty. All data was anonymized and stored securely throughout the research process.

### *Data analysis*

*For quantitative analysis*, nutritional analysis was performed to estimate the energy (kcal), protein (g), iron (mg), and vitamin C (mg) content of institutional meals provided by each pesantren. Nutrient values were calculated using NutriSurvey software based on the Indonesian Food Composition Table (Tabel Food Composition Indonesia, TKPI) [21]. Average daily nutrient provision was calculated from seven consecutive days of menu data. Nutritional adequacy was assessed by comparing mean daily nutrient values with the 2019 Indonesian Recommended Dietary Allowances (AKG) for adolescent girls aged 13–18 years [22]. Nutrient adequacy was expressed as a percentage of the recommended intake, and values below 80% of the AKG were classified as inadequate. Audio recordings of in-depth interviews and focus group discussions were transcribed verbatim and analyzed using thematic analysis. The analysis follows an inductive approach, involving repeated reading of transcripts, initial coding, identification of repetitive patterns, and the development of themes that reflect participants' experiences and perspectives on food provision in Islamic boarding schools. Theme coding and development are conducted iteratively to ensure the final theme accurately reflects the data. The qualitative and quantitative findings were synthesized during interpretation to yield a holistic understanding of institutional food provision and its possible ramifications for anemia risk in adolescent girls.

## RESULTS

Table 1 presents the weekly menu composition of the three Islamic boarding schools. During the seven-day observation period, all three institutions served staple foods, mostly rice, three times a day. This meant that each institution served the same amount of food every week, 21 times.

**Table 1:** Frequency of food group appearance in weekly menus by Pesantren

| Food Group | Pesantren A (times/week) | Pesantren B (times/week) | Pesantren C (times/week) |
|---|---|---|---|
| Staple (rice/carbohydrates) | 21 | 21 | 21 |
| Animal protein | 11 | 10 | 21 |
| Plant-based protein | 7 | 7 | 3 |
| Vegetables | 7 | 7 | 11 |
| Fruits | 7 | 1 | 7 |

This consistency reflects the central role of rice as the basis of the diet for all meals at the institutions, a pattern characteristic of Indonesian food culture and institutional catering practices. A striking difference emerged in the provision of animal protein sources. Pesantren C provided animal protein—consisting of eggs, chicken, and fish—at every meal (21 times per week), while Pesantren A and Pesantren B offered animal protein 11 and 10 times per week, respectively. This difference has direct nutritional significance: animal protein sources provide heme iron, which has a much higher bioavailability than the non-heme iron found in plant-based alternatives. Conversely, plant-based protein sources—tofu and tempeh—appeared more frequently on the menus of Pesantren A and B (7 times per week each) than at Pesantren C (3 times per week), consistent with Pesantren C's greater reliance on animal protein. Vegetable provision also varied across institutions. Pesantren C included vegetables in 11 meal services per week, compared to 7 in both

Pesantren A and B. While vegetables were present in all three menus, their frequency remained below the level required to ensure adequate micronutrient diversity across all daily meals. The most striking inter-institutional gaps are observed in the provision of fruit. Pesantren A and Pesantren C each serve fruit 7 times a week (once in a row), while Pesantren B provides fruit only 1 time during the entire seven-day observation period. Fruit serves as the principal source of vitamin C, which facilitates non-heme iron absorption; its near-complete exclusion from Pesantren B's menu may meaningfully compromise iron bioavailability and elevate anemia risk. Overall, the menu composition data reveals a pattern of limited dietary diversity across the three institutions, characterized by a heavy reliance on staple carbohydrates and plant proteins, with limited provision of heme iron-rich animal foods. The striking exception of fruit provision at Pesantren A and C—in contrast to the near absence of fruit at Pesantren B—is the most striking nutritional difference across the three menus, with direct implications for vitamin C availability and iron bioavailability, as confirmed by the nutrient content analysis presented below. Table 2 presents the average daily nutrient content of menus provided by the three pesantren, compared with the 2019 Indonesian Recommended Dietary Allowances (AKG). Using 80% of the AKG as the adequacy threshold, only energy provision at Pesantren C met this criterion for both age groups of adolescent girls.

**Table 2**: Mean daily nutritional content of menus compared to the Recommended Dietary Allowance (AKG)

| Nutrient | AKG | Pesantren A | | Pesantren B | | Pesantren C | |
|---|---|---|---|---|---|---|---|
| | | Mean/day | % AKG | Mean/day | % AKG | Mean/day | % AKG |
| ***Energy (kcal)*** | | | | | | | |
| 13-15 years | 2050 | 1605.4 | 78.3 | 1454.7 | 71.0 | 1731.6 | 84.5* |
| 16-18 years | 2100 | 1605.4 | 76.4 | 1454.7 | 69.3 | 1731.6 | 82.5* |
| Protein (g) | 65 | 43.1 | 66.4 | 40.1 | 61.6 | 46.9 | 72.2 |
| Iron/Fe (mg) | 15 | 7.8 | 52.2 | 7.0 | 47.0 | 9.1 | 60.4 |
| ***Vitamin C (mg)*** | | | | | | | |
| 13-15 years | 65 | 17.3 | 26.6 | 6.9 | 10.7 | 34.9 | 53.7 |
| 16-18 years | 75 | 17.3 | 23.1 | 6.9 | 9.2 | 34.9 | 46.5 |

AKG: Nutritional Adequacy Rate for adolescent girls (2019) aged 13–18 years. *Values ≥ 80% of AKG are categorized as adequate.

All other nutrient values fell below the recommended level, indicating widespread nutritional inadequacy across the three institutions. Energy adequacy ranged from 69.3%–71.0% of the AKG in Pesantren B, 76.4%–78.3% in Pesantren A, and 82.5%–84.5% in Pesantren C. Protein intake was also insufficient in all pesantren, reaching only 61.6%–72.2% of the recommended intake. Iron intake was substantially below requirements, providing only 47.0%–60.4% of the AKG, which is particularly concerning given the increased iron requirements of adolescent girls and the predominance of non-heme iron sources in the menus. Vitamin C inadequacy was the most pronounced finding. Adequacy levels ranged from only 9.2%–10.7% of the AKG in Pesantren B to 23.1%–26.6% in Pesantren A and 46.5%–53.7% in Pesantren C. The extremely low values observed in Pesantren B reflected the minimal provision of fruit, while the continued inadequacy in Pesantren A and C suggests that both the quantity and variety of vitamin C-rich foods remained insufficient. The quantitative findings indicate that the institutional menus provided at the three Islamic boarding schools are generally inadequate in meeting the nutritional needs of adolescent girls, particularly iron and vitamin C, nutrients closely linked to anemia prevention. To elucidate the factors underlying these nutritional gaps, in-depth interviews with kitchen managers were conducted to examine food provisioning practices, menu planning, and structural barriers to adequate food preparation in the boarding school setting. All three kitchen managers stated that the menus were prepared by the kitchen manager, with the foundation's approval. Thematic analysis of interviews with kitchen managers identifies the existence of budget constraints as a structural challenge that affects menu quality and food diversity. Kitchen managers consistently report that limited financial resources limit the preparation of protein foods from animal sources. Daily meal costs range from approximately Rp 7,500 to Rp 12,000 per student, which participants believe is insufficient to consistently provide a nutritionally diverse diet. As one kitchen manager explained, *"We cook according to the available budget. Because it is limited, we cook tofu and tempeh more often because they are cheaper than chicken or fish"* (Kitchen Manager, Pesantren A). These constraints were particularly evident in Pesantren B, where menus relied predominantly on plant-based protein sources throughout the week. Another recurring finding was the absence of personnel with a nutritional background in institutional kitchen management. In all Islamic boarding schools, food preparation and menu planning are handled by staff without a background in nutrition or food service. Although participants recognized the importance of balanced nutrition, they acknowledged limited practical knowledge regarding planning nutritious menus under existing budget constraints. One participant stated, *"I do not have a background in nutrition; I graduated in English studies"* (Kitchen Manager, Pesantren B), while another explained, *"I am only a high school graduate"* (Kitchen Manager, Pesantren B). A different pattern was observed in Pesantren C, where the kitchen manager had prior experience in a corporate foodservice setting. Although lacking formal nutrition education, this experience appeared to contribute to more structured and varied menu preparation. As the participant noted, *"I am a high school graduate, but I worked in a company kitchen for five years, so I am accustomed to preparing menus"* (Kitchen Manager, Pesantren C). Menu planning practices in all three pesantren were also largely shaped by institutional habits and

previous experience rather than by nutritional considerations or standardized dietary guidelines. Kitchen managers described menus as relatively unchanged over long periods, with food selection primarily determined by routine practices and ingredient availability. One participant explained, "I prepare menus based on previous experience and existing habits in the pesantren*"* (Kitchen Manager, Pesantren B). Compared with Pesantren A and B, Pesantren C demonstrated slightly greater menu diversity, including regular fruit provision, which was absent during the seven-day menu documentation period in the other two institutions, as observed in previous work. *"At the previous workplace, fruit ingredients were served every day, and I also instituted Islamic boarding schools"* (Kitchen Manager, Pesantren C). This practice is nutritionally significant, as fruit represents a primary dietary source of vitamin C—a key promoter of non-heme iron absorption. Compounding the budgetary constraints and lack of expertise, these food management systems operate without any evaluation and without involving the students' perspectives. None of the pesantren maintained formal mechanisms to monitor meal acceptability or student satisfaction. Instead, feedback loops were completely informal and broken up, depending on occasional verbal complaints that were passed on by third parties: "There has never been a formal evaluation; at most, there are verbal complaints passed on by the dormitory supervisor." (Kitchen Manager, Pesantren B). The absence of systematic evaluation suggests that students' eating experiences, including dissatisfaction with menus, food avoidance behaviors, and unmet dietary expectations, have not been adequately considered within institutional food management practices across the three pesantren.

These findings indicate that institutional food provision in the pesantren was shaped not only by financial limitations but also by the absence of nutrition-based menu planning and formal mechanisms for evaluating meal acceptability. To further understand how students experienced these conditions, FGDs were conducted with adolescent female students to explore their perceptions of the meals provided and their eating practices within the pesantren environment. Focus group discussions conducted with female adolescent students across the three pesantrens revealed two principal themes: a general perception of food sufficiency alongside dissatisfaction with menu monotony and habitual consumption of nutritionally poor foods outside the institutional kitchen. Findings from focus group discussions across all three pesantrens revealed that the food served at the boarding school is sufficient and filling, but the students consistently reported that they are *"bored because the menu is repetitive"* (Female student, Pesantren B, 16 years). This fatigue led to a critical aversion to vegetables, which students "*frequently leave unfinished*" (female student, Pesantren C, 17 years). Given that these vegetables are the primary source of vitamin C, this behavioral pattern significantly compromises their actual intake of this micronutrient. To reduce this monotony, students exercised their dietary choices within institutional limits by purchasing nutrient-poor, energy-dense snacks from campus canteens. Students noted that they *"buy snacks such as cimol and basreng"* and choose sweetened drinks when thirsty because "*they are refreshing"* (Female student Pesantren A, 17 years). Importantly, these behaviors were consistent across all pesantren, regardless of food budgets (Table 3).

**Table 3:** Summary of themes from focus group discussions with female adolescent students

| Theme | Key findings | Nutritional implication | Differences across Pesantren |
|---|---|---|---|
| Perceived sufficiency with limited variety | Food perceived as sufficient; monotonous menus caused dissatisfaction and reduced intake, vegetables were not consumed | Actual vitamin C intake is lower than the menu estimate | No significant differences were observed across institutions. |
| Supplementary food from outside kitchen | Regular consumption of snacks, nutritionally poor options are common | Worsening the nutritional deficit, no additional intake of Fe and vitamin C | No significant differences observed across institutions |

## DISCUSSION

This mixed-methods study examined food provision practices and their potential contribution to anemia risk among adolescent girls in Islamic boarding schools (pesantren). Results indicated that only energy met the recommended intake, and even then only in Pesantren C. Menus at all three institutions failed to meet the recommended nutritional requirements for protein, iron, and vitamin C, with most nutrients falling below 80% of the 2019 Indonesian Recommended Dietary Allowances (AKG). The qualitative study identified interrelated structural barriers: limited food budgets, the absence of trained nutritionists, and menu planning based largely on institutional customs and traditions rather than on nutritional principles and evaluation. Students also exhibited snacking habits that did not support their nutritional needs and perceived the meals as monotonous and lacking variety. Despite these shortcomings, students perceived the meals as adequate in terms of quantity, suggesting that micronutrient deficiencies often go unnoticed in daily eating practices. Therefore, combining quantitative and qualitative approaches in evaluating institutional food systems is crucial. Iron intake in the three Islamic boarding schools ranged from 47.0% to 60.4% of the Recommended Dietary Allowance (RDA), with the lowest sufficiency in Pesantren B. This finding aligns with prior evidence documenting inadequate iron intake among adolescent girls residing in Islamic boarding school settings [2,17,23,24]. These results align with broader evidence show that inadequate iron intake remains a major cause of anemia among adolescent girls in low- and middle-income countries [7]. Monotonous and less varied diets can limit iron intake [25]. A meta-analysis found that low dietary diversity was associated with an increased risk of anemia in children as well as adolescents [26]. Taken together, these findings suggest that inadequate iron

provision in pesantren reflects a broader systemic challenge rather than an institution-specific problem. Low animal protein consumption further exacerbates iron deficiency. Non-heme iron from plant foods has a much lower bioavailability (2-20%) than heme iron from animal sources (15-35%) [27]. Adequate vitamin C intake is essential to increase non-heme iron absorption up to 6-fold when consumed with plant iron sources [23,28]; however, the findings suggest that vitamin C from the served food is also insufficient. Vitamin C deficiency is particularly prominent, ranging from 10.7% to 53.7% of the RDA for girls aged 13–15 years and from 9.2% to 46.5% for girls aged 16–18 years. Iron requirements in adolescent girls increase substantially due to physiological needs associated with menstruation and pubertal growth [29]. Adolescent girls have higher iron needs because of the physical demands of growth and menstruation. This makes it very important to ensure they get enough iron and vitamin C at the same time. Studies show that simultaneous iron and vitamin C supplementation improves hemoglobin status more effectively than iron supplementation alone [30,31]. Focus group discussions (FGDs) revealed that many students do not consume vegetables, a source of vitamin C, in their diet, in line with findings in Poland, Denmark, and China [32–34]. This condition causes a much lower intake of vitamin C than that calculated from the menu portion. Therefore, simultaneous iron and vitamin C deficiencies constitute a combined nutritional risk that can substantially increase susceptibility to anemia. Adding herbs and spices to vegetables appears to increase their appeal to young women, offering one way to promote vegetable consumption in this age group [35]. Beyond micronutrient inadequacies, insufficient energy and protein intake may further undermine overall nutritional status. Protein deficiency can impair transferrin synthesis and iron transport, reducing the body's ability to utilize iron effectively [36]. Similar findings among Indonesian adolescents indicate that anemia often coexists with broader dietary inadequacies rather than isolated micronutrient deficiencies [37]. Qualitative findings help explain why this malnutrition persists. Financial constraints were a recurrent barrier to the provision of animal-source foods, fruits, and diverse vegetables, echoing challenges widely reported in similar resource-limited institutional settings [38]. The absence of nutrition-trained personnel may further compromise menu quality, as food planning often prioritizes affordability and familiarity over nutritional adequacy [39]. A notable difference was observed at Pesantren C, where the kitchen manager had five years of professional experience in food service. Although not formally trained in nutrition, this experience appeared to contribute to more structured menu planning, greater menu rotation, and consistent inclusion of fruit. This finding suggests that practical foodservice experience may contribute to menu quality, although it cannot substitute for formal nutrition expertise. Previous studies have similarly shown that staff training can improve knowledge, leadership, and foodservice practices [40]. Without structured student evaluation, critical misalignments between menu provision and student needs may go undetected, with downstream consequences for food acceptance and dietary intake [41]. Regular evaluation can identify gaps between menu offerings and students' preferences, thereby informing menu improvements and supporting adequate food intake [42]. Chelly *et al*. similarly linked substantial food waste in residential settings to menus misaligned with eating habits and preferences [43]. Routine monitoring of dietary intake and nutritional status is critical for the timely detection and prevention of malnutrition among adolescents [24]. Collectively, these findings emphasize the necessity of nutrition-sensitive food management within pesantren settings. Feasible entry points include menu diversification, improved availability of iron- and vitamin C-rich foods, nutrition training for kitchen staff, and the incorporation of student feedback mechanisms to enhance dietary quality and mitigate anemia risk.

## Study Limitations

While this study provides useful information about an underexplored dimension of institutional food environments, several limitations merit acknowledgment. The nutritional analysis was based on *institutional menus rather than individual dietary intake, and no biochemical indicators of anemia were collected.* Furthermore, the study was limited to three purposefully selected Islamic boarding schools (pesantren) in a single district. Future studies combining dietary assessment, anemia screening, food acceptability evaluation, and broader geographic sampling are needed to strengthen the evidence base for nutrition-sensitive interventions in Islamic boarding schools.

## Conclusion

This study demonstrated that food provision in three Islamic boarding schools located in Salopa, Rajapolah, and Manonjaya, Tasikmalaya, West Java, was insufficient to meet the nutritional needs of adolescent girls, particularly for iron and vitamin C, two nutrients essential for anemia prevention. The consistency of these findings across institutions suggests that nutritional inadequacies in pesantren food provision reflect broader systemic challenges rather than isolated institutional shortcomings. Qualitative findings identified limited food budgets, the absence of nutrition-trained personnel, and menu planning based largely on established practices rather than nutritional considerations as key factors contributing to poor dietary quality. The finding that students generally perceived the meals as adequate despite objectively inadequate nutrient content further emphasizes the necessity to address anemia risk through improvements in the institutional food environment, in addition to individual-level interventions. Prioritizing nutrition-sensitive food management—through menu diversification, greater provision of locally available iron- and vitamin C-rich foods, and integration of nutrition expertise into menu

planning—is essential to support anemia prevention among adolescent girls in pesantren settings.

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### Conflict of interests

The authors declared no conflict of interest.

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### Data sharing statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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