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Nutritional Status and Anemia-Related Knowledge as Correlates of Maternal Hemoglobin Concentration: A Cross-Sectional Study Among Third-Trimester Pregnant Women

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ABSTRACT

Maternal anemia continues to pose substantial public health challenges in Indonesia, with consequences extending to pregnancy outcomes and child development. Mid-upper arm circumference (MUAC) offers a practical nutritional assessment in resource-limited settings, while anemia-related knowledge represents the cognitive dimension of maternal health literacy relevant to preventive behaviors. This study examined the relationships of maternal nutritional status measured through MUAC and anemia-related knowledge with hemoglobin concentrations among third-trimester pregnant women in rural Indonesia. A cross-sectional analytical study was conducted from May to August 2024 at Palang Health Center, Tuban Regency. Through purposive sampling, 232 third-trimester pregnant women were recruited. Data collection involved MUAC measurements using standardized tape, hemoglobin assessment via digital hemoglobinometer, and a validated 20-item anemia knowledge questionnaire. Statistical analyses included descriptive statistics, Chi-square tests, and multiple linear regression at $\alpha=0.05$. Anemia prevalence was 37.9%. Significant associations were observed between nutritional status and anemia status ($p<0.001$) and between anemia-related knowledge and anemia status ($p<0.001$). Women with MUAC below 23.5 cm had a higher anemia prevalence (78.2%) than those with adequate MUAC (17.5%); women with poor knowledge had an anemia prevalence of 87.5% versus 20.0% among those with good knowledge. In the linear regression model, each 1-cm increase in MUAC was associated with a 0.112 g/dL higher hemoglobin concentration ($B=0.112$, $p<0.001$), and each one-point increase in knowledge score was associated with a 0.286 g/dL higher hemoglobin concentration ($B=0.286$, $p=0.002$). The model explained 41.2% of hemoglobin variance ($R^2=0.412$). MUAC and anemia-related knowledge are significant correlates of hemoglobin levels in late pregnancy. Comprehensive anemia prevention strategies may integrate anthropometric screening, individualized nutritional counseling, structured anemia education, and promotion of locally accessible iron-rich foods.

Keywords : *Anthropometric assessment; anemia-related knowledge; health literacy; maternal nutrition; pregnancy.*

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INTRODUCTION

Maternal anemia represents a persistent global public health challenge, particularly affecting low- and middle-income countries where nutritional deficiencies remain prevalent. This condition, characterized by hemoglobin concentrations below 11.0 g/dL during pregnancy, results primarily from iron deficiency compounded by increased physiological demands of gestation (14). The implications extend beyond immediate maternal health to encompass fetal development, birth outcomes, and long-term child health trajectories. Anemia during pregnancy elevates risks for preterm delivery, low birth weight, intrauterine growth restriction, postpartum hemorrhage, and maternal mortality while compromising maternal immune function and cognitive performance (16).

Global epidemiological data from the World Health Organization indicates that approximately 40% of pregnant women worldwide experience anemia, with regional variations reflecting underlying nutritional, socioeconomic, and healthcare access disparities. The Southeast Asian region demonstrates particularly high prevalence rates approaching 48%, signaling widespread inadequacies in maternal iron status. Within Indonesia, the 2023 Basic Health Research documented maternal anemia prevalence of 48.9%, representing an increase from 37.1% in 2018 despite ongoing supplementation programs. This upward trend suggests that current intervention strategies require reevaluation and enhancement to effectively address the multifactorial determinants of maternal anemia.

Regional data from East Java Province reveals anemia prevalence of 47.5% among pregnant women, with Tuban Regency reporting that approximately 45% of pregnant women attending health facilities demonstrate below-normal hemoglobin concentrations. These figures underscore the magnitude of the problem in rural settings where access to diverse nutritious foods and comprehensive health education may be limited. Understanding the modifiable factors contributing to maternal anemia in these contexts becomes essential for developing targeted, culturally appropriate interventions that can be implemented within existing primary healthcare systems.

The pathophysiology of anemia during pregnancy involves complex interactions between physiological adaptations and nutritional adequacy. Pregnancy induces a 40-50% increase in plasma volume while erythrocyte mass expands only 15-20%, resulting in physiological hemodilution (10). Although this represents a normal adaptive response, it becomes pathological when inadequate iron, folate, and protein intake prevents compensatory increases in hemoglobin production. Iron requirements during pregnancy escalate substantially to support expanded maternal blood volume, placental development, fetal growth, and preparation for blood loss during delivery (8). When dietary intake and body stores prove insufficient, progressive depletion of iron reserves leads to iron-deficient erythropoiesis and ultimately iron deficiency anemia.

Maternal nutritional status serves as a fundamental determinant of hemoglobin concentrations through its influence on substrate availability for erythropoiesis. Mid-upper arm circumference provides a practical, low-cost anthropometric indicator of nutritional status that reflects both subcutaneous fat and muscle mass, thereby indicating adequacy of energy and protein reserves. In resource-limited primary care settings, mid-upper arm circumference offers distinct advantages over more complex nutritional assessment methods, requiring only an inexpensive measuring tape and minimal training. Previous research has established associations between low mid-upper arm circumference and increased anemia risk, with pregnant women having measurements below 23.5 cm demonstrating substantially higher anemia prevalence(12). The physiological basis for this relationship involves protein-energy malnutrition limiting amino acid availability for globin synthesis, impairing overall metabolic capacity for erythropoiesis, and typically accompanying multiple micronutrient deficiencies essential for hemoglobin formation (3,6).

Beyond physiological factors, maternal anemia-related knowledge represents an important behavioral factor influencing dietary choices, supplement adherence, and health-seeking behaviors. In this study, health literacy is operationalized specifically as anemia-related knowledge, representing its cognitive dimension rather than the broader multidimensional construct. This knowledge encompasses understanding of anemia causes, consequences, prevention strategies, symptoms, iron-rich foods, factors affecting iron absorption, and iron supplementation. Women with stronger anemia-related knowledge may be better equipped to make informed dietary choices, understand prenatal iron supplementation, and recognize symptoms that warrant timely care (1,11,13).

Despite recognition of nutritional status and anemia-related knowledge as potentially important factors in maternal anemia, limited research has examined their simultaneous associations with hemoglobin concentrations in Indonesian rural settings where anemia prevalence remains high (15). Understanding these modifiable correlates is important for designing contextually appropriate interventions that can be integrated into existing antenatal care services. This study addresses this gap by examining the relationships of maternal nutritional status measured through mid-upper arm circumference and anemia-related knowledge with hemoglobin concentrations among third-trimester pregnant women in rural Tuban Regency.

The specific objectives of this research were threefold. First, to describe the distribution of nutritional status, anemia-related knowledge, and hemoglobin levels among third-trimester pregnant women in the study setting. Second, to examine bivariate associations between nutritional status and anemia prevalence, and between anemia-related knowledge and anemia prevalence. Third, to examine the simultaneous associations of MUAC and anemia-related knowledge scores with hemoglobin concentrations using multiple linear regression. The findings are expected to inform evidence-based strategies for strengthening anemia prevention within primary healthcare services in Indonesia.

METHODS

This quantitative analytical study employed a cross-sectional design to examine the relationships between maternal nutritional status, anemia-related knowledge, and hemoglobin concentrations among third-trimester pregnant women. The study was conducted at Palang Health Center, Palang District, Tuban Regency, East Java Province,

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Indonesia, from May through August 2024. The study site was purposively selected based on local health office surveillance data indicating a high anemia prevalence of 45% among pregnant women and representing a typical rural primary healthcare setting with limited resources and restricted access to diverse nutritious foods. The accessible population comprised 320 third-trimester pregnant women registered at the health center during the study period. Sample size was calculated using the Lemeshow formula for cross-sectional studies with an expected population proportion of 45%, 95% confidence level, and 5% precision margin, yielding a minimum required sample of 232 respondents. Participants were recruited through purposive sampling based on predetermined inclusion and exclusion criteria. Inclusion criteria were gestational age of 28–40 weeks confirmed by last menstrual period or ultrasound examination, willingness to participate indicated by written informed consent, permanent residence within Palang District, and ability to communicate in Indonesian language. Exclusion criteria included severe pregnancy complications such as preeclampsia, eclampsia, or antepartum hemorrhage, medication therapy other than routine prenatal vitamins and iron supplements, and chronic diseases affecting hemoglobin concentrations, including thalassemia, chronic kidney disease, or other hemoglobinopathies. The dependent variable was hemoglobin concentration, measured in g/dL using a digital hemoglobinometer and categorized according to World Health Organization criteria as anemia (hemoglobin <11.0 g/dL) or normal (hemoglobin ≥11.0 g/dL), while also analyzed as a continuous variable in regression modeling. Independent variables included maternal nutritional status and anemia-related knowledge. Nutritional status was assessed through mid-upper arm circumference measurement using a standardized tape, recorded in centimeters, and categorized as low nutritional status (MUAC <23.5 cm, indicating chronic energy deficiency risk) or normal nutritional status (MUAC ≥23.5 cm) according to Indonesian Ministry of Health guidelines; MUAC was also treated as a continuous variable in multivariate analysis. Anemia-related knowledge was evaluated using a structured questionnaire consisting of 20 multiple-choice items covering anemia definition and causes, symptoms, maternal and fetal consequences, prevention strategies, iron-rich food sources, factors affecting iron absorption, and iron supplementation. Each correct answer scored one point, producing a total score range of 0–20, with knowledge categorized as poor (0–10), moderate (11–15), or good (16–20), and analyzed as a continuous variable in regression analysis.

Three validated instruments were used for data collection, including a standardized non-stretchable measuring tape for mid-upper arm circumference (MUAC), a Mission Plus digital hemoglobinometer (measurement range 0–25.6 g/dL; accuracy ±0.5 g/dL) for hemoglobin assessment, and a validated 20-item anemia-related knowledge questionnaire with good internal consistency (Cronbach's $\alpha = 0.847$). Data were collected by three trained midwives following standardized procedures during antenatal care visits. After obtaining written informed consent, MUAC was measured three times and averaged, hemoglobin concentration was determined through capillary finger-prick blood sampling, and the questionnaire was administered through face-to-face interviews to ensure response accuracy and completeness. Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics were used to summarize participant characteristics and study variables, while Chi-square tests assessed associations between nutritional status, anemia knowledge, and anemia status. Multiple linear regression was performed to determine the simultaneous associations of MUAC and anemia-related knowledge scores with hemoglobin concentration after confirming assumptions of normality, linearity, homoscedasticity, independence, and absence of multicollinearity. Statistical significance was set at $p < 0.05$. Ethical approval was obtained from the Health Research Ethics Committee of Nahdlatul Ulama Institute of Health Sciences Tuban (No. 53/0084223523/LEPK.IIKNU/III/2025). Written informed consent was obtained from all participants, confidentiality was maintained throughout the study, and participants diagnosed with anemia were referred for appropriate clinical management, including iron supplementation, nutritional counseling, and follow-up care.

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RESULTS

Participant Characteristics

A total of 232 third-trimester pregnant women participated in this study, representing 72.5% of the accessible population. Table 1 presents the distribution of sociodemographic and obstetric characteristics. The majority of participants (73.3%, n=170) were aged 20-35 years, representing the optimal reproductive age range. Younger participants aged below 20 years comprised 12.9% (n=30), while 13.8% (n=32) were aged above 35 years, a group potentially at higher risk for pregnancy complications.

Educational attainment showed that approximately half of participants (49.1%, n=114) had completed senior high school education, while 40.5% (n=94) had junior high school education, and 10.4% (n=24) had achieved higher education. This educational distribution reflects typical patterns in rural Indonesian settings where access to tertiary education remains limited. Regarding parity, primigravida women constituted the majority (65.5%, n=152), with multigravida women representing 34.5% (n=80) of the sample (table 1).

Table 1. Sociodemographic and Obstetric Characteristics of Participants (N=232)

Characteristics	Category	Frequency (n)	Percentage (%)
Age (years)			
	<20	30	12.9
	20–35	170	73.3
	>35	32	13.8
Education Level			
	Junior High School	94	40.5
	Senior High School	114	49.1
	Higher Education	24	10.4
Parity			
	Primigravida	152	65.5
	Multigravida	80	34.5

Distribution of Study Variables

Table 2 presents the distribution of nutritional status assessed through mid-upper arm circumference measurements. Approximately two-thirds of participants (66.4%, n=154) demonstrated normal nutritional status with mid-upper arm circumference ≥23.5 cm, while one-third (33.6%, n=78) had low nutritional status with measurements below this threshold. The mean mid-upper arm circumference was 24.8±2.3 cm, with values ranging from 19.5 to 31.2 cm. The substantial proportion of women with low mid-upper arm circumference indicates significant chronic energy deficiency risk in this population.

Table 2. Distribution of Nutritional Status, Anemia-Related Knowledge, and Hemoglobin Status (N=232)

Variable	Category	n	%	Summary
MUAC status	Low (<23.5 cm)	78	33.6	Mean ± SD: 24.8 ± 2.3 cm
	Normal (≥23.5 cm)	154	66.4	Range: 19.5–31.2 cm
Knowledge	High	110	47.4	Mean ± SD: 14.6 ± 3.8
	Moderate (11–15)	82	35.3	Range: 6–20
	Poor (0–10)	40	17.3	
Hemoglobin status	Anemia (<11.0 g/dL)	88	37.9	Mean ± SD: 11.4 ± 1.2 g/dL
	Normal (≥11.0 g/dL)	144	62.1	Range: 8.2–14.6 g/dL
	Total	232	100.0	

Sources : Primary data 2024

Table 2 shows the distribution of anemia-related anemia-related knowledge levels among participants. Nearly half of participants (47.4%, n=110) demonstrated good knowledge about anemia, while 35.3% (n=82) had moderate knowledge, and 17.3% (n=40) exhibited poor knowledge. The mean knowledge score was 14.6±3.8 out of a maximum possible score of 20. Although the proportion with good knowledge is encouraging, the combined 52.6% with moderate or poor knowledge highlights important gaps in health literacy that may contribute to anemia risk.

Table 2 presents the prevalence of anemia among third-trimester pregnant women in this study. More than one-third of participants (37.9%, n=88) had hemoglobin concentrations below 11.0 g/dL, meeting criteria for anemia, while 62.1% (n=144) maintained normal hemoglobin levels. The mean hemoglobin concentration was 11.4±1.2 g/dL, with values ranging from 8.2 to 14.6 g/dL. This 37.9% prevalence represents a moderate public health problem according to World Health Organization classification criteria.

Bivariate Analysis

Table 5 demonstrates a statistically significant association between nutritional status and anemia prevalence (χ^2=42.156, p<0.001). Among women with low mid-upper arm circumference, the vast majority (78.2%, n=61) experienced anemia, while only 21.8% (n=17) maintained normal hemoglobin levels. In contrast, among women with normal mid-upper arm circumference, only 17.5% (n=27) had anemia while 82.5% (n=127) had normal hemoglobin concentrations. This represents a 4.5-fold difference in anemia prevalence between nutritional status groups.

Table 3. Associations of MUAC Status and Anemia-Related Knowledge with Anemia Prevalence (N=232)

Variable / Category	Anemia n(%)	Normal n(%)	Total n(%)	p-value
MUAC: Low (<23.5 cm)	61 (78.2)	17 (21.8)	78 (100)	<0.001*
MUAC: Normal (≥23.5 cm)	27 (17.5)	127 (82.5)	154 (100)	
Anemia knowledge: Good	22 (20.0)	88 (80.0)	110 (100)	<0.001*
Anemia knowledge: Moderate	31 (37.8)	51 (62.2)	82 (100)	
Anemia knowledge: Poor	35 (87.5)	5 (12.5)	40 (100)	
Total	88 (37.9)	144 (62.1)	232 (100)	

Sources : Primary data 2024

*Chi-square test, significant at p<0.05

Table 3 shows a significant association between anemia-related knowledge levels and anemia status (χ^2=28.445, p<0.001). Among women with poor knowledge, an overwhelming 87.5% (n=35) had anemia compared to only 12.5% (n=5) with normal hemoglobin levels. Women with moderate knowledge showed intermediate anemia prevalence of 37.8% (n=31). Notably, among women with good knowledge, only 20.0%

(n=22) experienced anemia while 80.0% (n=88) maintained normal hemoglobin concentrations.

Multivariate Analysis

Table 4 presents multiple linear regression results. The overall model achieved statistical significance (F=15.89, p<0.001), with R^2=0.412, indicating that mid-upper arm circumference and knowledge jointly explained 41.2% of hemoglobin variance. Mid-upper arm circumference showed a positive significant association (B=0.112, 95% CI: 0.059-0.165, p<0.001), meaning each 1 cm increase in mid-upper arm circumference associated with 0.112 g/dL higher hemoglobin. Knowledge score also demonstrated a positive significant association (B=0.286, 95% CI: 0.107-0.465, p=0.002), with each one-point increase associated with 0.286 g/dL higher hemoglobin.

Table 4. Multiple Linear Regression Analysis of Factors Affecting Hemoglobin Levels

Variable	B	SE	β	t	p-value	95% CI
Constant	8.421	0.352	-	23.91	<0.001	7.727-9.115
MUAC (cm)	0.112	0.027	0.241	4.15	<0.001*	0.059-0.165
Knowledge Score	0.286	0.091	0.182	3.14	0.002*	0.107-0.465

Sources : Primary data 2024

Model: R^2=0.412; Adjusted R^2=0.407; F=15.89, p<0.001
*Significant at p<0.05

DISCUSSION

This cross-sectional study examined relationships between maternal nutritional status, anemia-related knowledge (the cognitive dimension of health literacy measured in this study), and hemoglobin concentrations among 232 third-trimester pregnant women in rural Indonesia. The findings show an anemia prevalence of 37.9% and significant associations of both MUAC and anemia-related knowledge with hemoglobin status and concentration.

Anemia Prevalence in Context

The observed anemia prevalence of 37.9% among third-trimester pregnant women, while representing a moderate public health problem according to World Health Organization classification, falls below the national average of 48.9% and the East Java provincial rate of 47.5% reported in 2023 Basic Health Research data. This relatively lower prevalence may reflect local health promotion efforts, geographic variations in dietary patterns, or differences in measurement methods across studies. Nevertheless, the finding that more than one-third of women entering the final trimester of pregnancy have inadequate hemoglobin concentrations indicates substantial room for improvement in anemia prevention strategies.

The mean hemoglobin concentration of 11.4±1.2 g/dL demonstrates that the population average remains only marginally above the anemia threshold, suggesting vulnerability to dietary fluctuations or other stressors. The wide range of observed values (8.2-14.6 g/dL) indicates substantial heterogeneity in iron status, underscoring the importance of identifying individual-level risk factors that differentiate women who maintain normal hemoglobin levels from those who develop deficiency(2).

Nutritional Status and Hemoglobin: Physiological Linkages

The strong association between mid-upper arm circumference and hemoglobin levels aligns with established physiological understanding. The finding that 78.2% of women with low mid-upper arm circumference experienced anemia compared to only 17.5% of those with normal measurements represents a 4.5-fold difference in risk, demonstrating the profound impact of chronic energy deficiency on hemoglobin maintenance during pregnancy.

This relationship operates through multiple interconnected mechanisms. Mid-upper arm circumference reflects subcutaneous fat and muscle mass, indicating adequacy of energy and protein reserves. Protein deficiency directly compromises hemoglobin synthesis by limiting amino acid availability for globin chain construction (6). Energy deficiency similarly affects erythropoiesis through reduced metabolic capacity for red blood cell production in bone marrow and impaired synthesis of erythropoietin hormone(3,8).

Furthermore, chronic energy deficiency typically coexists with multiple micronutrient deficiencies beyond iron, including folate, vitamin B12, vitamin A, vitamin C, copper, and zinc, all essential for erythropoiesis and hemoglobin formation (4,18). Poor nutritional status also affects iron absorption and utilization, with malnourished women often having compromised gastrointestinal function and suboptimal intake of absorption enhancers.

The dose-response relationship revealed in regression analysis, where each one-centimeter increase in mid-upper arm circumference corresponded to 0.112 g/dL higher hemoglobin, provides quantitative evidence supporting the clinical value of anthropometric monitoring. This gradient effect suggests that interventions successfully improving nutritional status would yield proportional benefits in hemoglobin concentrations. These findings align with previous research documenting associations between anthropometric indicators and anemia risk in pregnant populations(12,15).

Anemia-Related Knowledge as a Behavioral Correlate

The significant association between anemia-related knowledge and hemoglobin levels, with 87.5% of women with poor knowledge experiencing anemia compared with 20.0% of those with good knowledge, indicates an important behavioral correlate of maternal hematological status. This pattern remained statistically significant when MUAC and knowledge score were entered simultaneously in the regression model. Because the analysis did not adjust for maternal age, education, parity, or other potential confounders, the finding should not be interpreted as an independent causal effect.

These findings are consistent with literature examining the role of anemia-related knowledge in prevention behaviors. Better knowledge may support dietary choices, supplement adherence, and timely health-seeking, although knowledge alone does not capture the broader functional and communicative dimensions of health literacy(1,13,17).

The plausible pathways linking anemia-related knowledge with hemoglobin levels operate through behaviors affecting dietary intake, supplement adherence, and health-seeking. Knowledge can help women identify iron-rich foods, understand the role of vitamin C in supporting iron absorption, and avoid consuming tea close to iron-rich meals or iron supplementation. This issue is particularly relevant in Indonesia, where tea consumption is common and tannins may inhibit iron absorption; an Indonesian study among pregnant women in Makassar reported an association between tea-drinking habits and anemia(20).

The regression finding that each one-point increase in anemia-related knowledge score was associated with 0.286 g/dL higher hemoglobin provides a quantitative estimate of the observed relationship. However, given the cross-sectional design and lack of adjustment for sociodemographic and obstetric confounders, this coefficient should be interpreted as an association rather than evidence that increasing knowledge would directly raise hemoglobin. The substantial proportion of women with moderate or poor knowledge (52.6%) nevertheless identifies an important target for antenatal education(5,9).

Independent and Synergistic Effects

The multiple linear regression model showed that MUAC and anemia-related knowledge scores were both significantly associated with hemoglobin levels when entered simultaneously, together explaining 41.2% of hemoglobin variance. These findings suggest that nutritional status and the cognitive dimension of health literacy represent distinct correlates of hemoglobin concentration. The model was not adjusted for maternal age, education, parity, or other potential confounding variables; therefore, the term 'independent' here should not be interpreted as indicating confounder-adjusted causal effects.

The 41.2% explained variance represents a moderate to strong effect size, indicating these two modifiable factors account for substantial hemoglobin variability. However, the remaining 58.8% of unexplained variance suggests additional factors contribute, including genetic factors affecting iron metabolism, parasitic infections causing blood loss, chronic infections triggering inflammatory responses, specific dietary patterns, supplement compliance levels, birth spacing intervals, and environmental exposures(7).

The standardized beta coefficients (0.241 for mid-upper arm circumference versus 0.182 for knowledge) suggest that when accounting for different measurement scales, nutritional status had slightly greater relative importance. However, both coefficients indicate meaningful contributions, and interventions addressing both factors would likely achieve greater impact than those targeting only one dimension(4).

Implications for Clinical Practice and Public Health Programs

These findings have several important implications for improving anemia prevention. At the clinical care level, mid-upper arm circumference measurement should be integrated as a routine component of every antenatal care visit. This simple, rapid, low-cost assessment requires only an inexpensive measuring tape and provides valuable information for risk stratification. Women identified with low mid-upper arm circumference should receive intensified interventions including individualized nutrition counseling, possible referral to supplemental feeding programs, more frequent hemoglobin monitoring, and consideration of enhanced iron supplementation protocols(2).

Health education delivery requires substantial strengthening to address knowledge gaps. Rather than brief verbal counseling during busy visits, structured group education sessions should be implemented, utilizing culturally appropriate visual aids, demonstrations, and interactive methods. Educational content should extend beyond basic anemia information to include practical skills such as meal planning with iron-rich foods, strategies for managing supplement side effects, and symptom recognition prompting medical consultation(19).

Nutrition counseling should emphasize locally available, affordable iron-rich foods including dark green leafy vegetables (spinach, cassava leaves), legumes (soybeans, mung beans, peanuts), fortified foods, and animal sources like small fish consumed with bones. Practical cooking demonstrations may enhance adoption more effectively than abstract nutritional information. Addressing barriers to supplement adherence requires comprehensive counseling about expected side effects and management strategies, simplified reminder systems, and periodic follow-up for problem-solving(12).

Community-based interventions can extend anemia prevention beyond health facilities. Training community health workers for home visits, community gardens promoting iron-rich vegetables, cooking demonstrations sharing preparation methods, and engaging family members who influence household food allocation can create supportive environments for maternal nutrition.

From a health system perspective, strengthening anemia prevention requires adequate resource allocation, including continuous supplement availability, provision of measuring tapes and hemoglobinometers, standardized educational materials, and training of healthcare workers in nutrition counseling and effective communication. Multi-sectoral collaboration may also help address broader social and nutritional conditions that shape maternal anemia risk.

Strengths and Limitations

This study has several strengths, including standardized MUAC measurement, use of a validated anemia-related knowledge questionnaire, and simultaneous analysis of nutritional and cognitive-behavioral correlates of hemoglobin concentration in a rural primary-care population. Several limitations should be considered. First, the cross-sectional design establishes associations but cannot determine temporality or causality. Second, purposive sampling may introduce selection bias and limits generalizability beyond women attending the study health center. Third, hemoglobin was assessed using capillary finger-prick blood with a digital hemoglobinometer; although practical for field settings, capillary measurements are susceptible to pre-analytical and measurement variability(11). Fourth, the regression model included MUAC and anemia-related knowledge but did not adjust for potential confounders such as maternal age, education, parity, dietary intake, iron-supplement adherence, infection, or socioeconomic status. Residual confounding is therefore possible, and the regression coefficients should be interpreted as adjusted only for the other predictor included in the model.

CONCLUSIONS AND RECOMMENDATIONS

This study found that maternal nutritional status assessed through MUAC and anemia-related knowledge, representing the cognitive dimension of health literacy measured in this study, were significantly associated with hemoglobin concentrations among third-trimester pregnant women in rural Indonesia. When entered simultaneously in the regression model, MUAC ($B=0.112$, $p<0.001$) and anemia-related knowledge score ($B=0.286$, $p=0.002$) were significant correlates and together accounted for 41.2% of the variance in hemoglobin levels. Anemia prevalence was 37.9%, with higher prevalence among women with low MUAC and poor anemia-related knowledge. These findings identify nutritional status and anemia-related knowledge as potentially modifiable correlates rather than causal determinants.

The findings support the practical value of MUAC as a simple screening indicator for nutritional vulnerability in resource-limited primary care settings. The observed gaps in anemia-related knowledge also support strengthening structured antenatal education. Because the study was cross-sectional and used purposive sampling, these findings should be applied cautiously and should not be interpreted as evidence that changes in MUAC or knowledge necessarily cause changes in hemoglobin.

Anemia prevention programs may therefore combine routine anthropometric screening, targeted nutrition counseling using locally available iron-rich foods, anemia education, support for appropriate iron-supplement use, and attention to dietary practices that may affect iron absorption. Future longitudinal or intervention-based studies are recommended to evaluate the temporal impact of nutritional support and educational programs on maternal hemoglobin recovery and to adjust for maternal age, education, parity, dietary intake, supplement adherence, infection, and socioeconomic factors.

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