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Factors Associated with Anemia Among Pregnant Women in Indonesia: A Multivariable Analysis of the 2023 Indonesian Health Survey

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Abstract

Maternal anemia remains an important public health problem in Indonesia despite national iron-folic acid supplementation and antenatal care programs. Updated national evidence is needed to identify groups requiring more targeted prevention. This study examined factors associated with anemia among pregnant women in Indonesia using the 2023 Indonesian Health Survey. This was a cross-sectional analysis of secondary data from SKI 2023. The analysis included pregnant women with hemoglobin measurement and complete covariate information. The weighted analytical population represented 121,339 pregnant women; the exact unweighted analytic sample should be reported from the final cleaned dataset. Anemia was defined as hemoglobin <11 g/dL. Survey weights, strata, and primary sampling units/clusters were incorporated in the analysis. Weighted descriptive statistics, design-adjusted Rao-Scott chi-square tests, and survey-weighted multivariable logistic regression were used. Adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were reported. The weighted prevalence of anemia was 28.2%. In the adjusted model, anemia was associated with age at risk (<20 or >35 years) (AOR=1.69; CI: 1.63-1.74), being unemployed (AOR=2.46; CI: 2.38-2.55), irregular ANC visits (AOR=1.41; CI: 1.36-1.47), chronic energy deficiency (AOR=1.28; CI: 1.24-1.33), and non-adherence to iron-folic acid supplementation (AOR=1.44; CI: 1.40-1.48). Low maternal education (AOR=0.82; CI: 0.80-0.84) and incomplete ANC quality (AOR=0.34; CI: 0.32-0.36) showed inverse associations that require cautious interpretation because they may reflect coding/reference-category issues, detection bias, gestational-age-related measurement, or residual confounding. Strengthening design-based monitoring, targeted ANC counseling, and community-supported adherence strategies may help reduce anemia among pregnant women, particularly among economically vulnerable groups.

Keywords: antenatal care; chronic energy deficiency; iron supplementation; maternal anemia; maternal occupation

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Introduction

Anemia continues to represent a serious challenge in pregnancy, as it markedly increases the risk of morbidity and mortality among mothers, fetuses, and newborns. In 2019, the World Health Organization (WHO) estimated that nearly 40% of children under five years old and 37% of pregnant women globally were affected by anemia. The greatest burden has been documented in regions including West Africa, the Middle East, and South Asia (1).

In Indonesia, maternal anemia remains a significant public health concern. The prevalence was recorded at 37.1% in 2013 (2), and rose substantially to 48.9% in 2018, surpassing the global average for maternal anemia (3). However, data from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia/SKI) indicate a decline to 27.7%, reflecting a 21.2% reduction compared with the 2018 Basic Health Research (Riskesdas) results. The most pronounced decrease was observed among women aged 15–24 years, with prevalence falling from 84.6% to 14.5%. In contrast, among women aged 25–34 years, who account for the majority of pregnancies, the decline was modest, decreasing

only from 33.7% to 31.4% (a 2.3% reduction). One of the principal national interventions to combat maternal anemia is iron and folic acid supplementation. Although distribution coverage has reached 92.2%, adherence remains suboptimal, with only 44.2% of pregnant women consuming at least 90 tablets as recommended. Poor compliance with supplementation protocols continues to contribute to the sustained prevalence of maternal anemia (4).

Preventing maternal anemia effectively necessitates a thorough understanding of its determinants and associated risk factors. Iron deficiency remains the leading cause during pregnancy, responsible for roughly half of all cases; nevertheless, other contributing conditions must also be considered (5). The Epidemiologic Triangle model provides a useful framework for understanding these determinants by describing the interaction between host, agent, and environmental factors. Host factors encompass individual attributes that affect vulnerability or disease progression, including age, nutritional status, and biological characteristics. The agent represents the direct cause of the condition, such as iron deficiency or other pathological processes. Environmental factors involve external influences that either promote or limit disease occurrence, including socioeconomic conditions, healthcare accessibility, sanitation, and living environments (6–8).

In the Indonesian context, the prevention of anemia among pregnant women is not only related to biological factors, nutritional status, and access to health services, but is also influenced by social, cultural, family, and community contexts. Maternal health behaviors, including adherence to iron–folic acid supplementation, regular antenatal care attendance, and acceptance of nutritional education, are often shaped by family norms, husband's support, community beliefs, and the influence of community leaders. Therefore, maternal anemia should be understood as a multidimensional public health problem (6–9).

Furthermore, socio-religious settings play an important role in shaping health behaviors within communities. Religion and faith-based communities may serve as sources of social support, channels for disseminating health information, mechanisms for reinforcing positive norms, and means of increasing public trust in health messages. In the context of maternal and child health, religious leaders and faith-based organizations have the potential to support maternal health promotion by providing education on the importance of antenatal care, adherence to iron–folic acid supplementation, adequate nutrition during pregnancy, and family support for pregnant women. Thus, the study of factors associated with anemia among pregnant women is relevant to the scope of religion and public health, as its findings may provide a basis for strengthening community-based maternal health interventions grounded in socio-religious values (6–8,10).

Maternal anemia, particularly iron deficiency anemia, remains a pressing global health issue due to its association with unfavorable pregnancy outcomes. Recent evidence has reinforced these concerns. A 2025 meta-analysis demonstrated that maternal anemia significantly elevates the risk of postpartum hemorrhage (RR 2.76), premature rupture of membranes (RR 1.94), preterm delivery (RR 1.51), low birth weight (RR 1.40), cesarean section (RR 1.28), gestational hypertension (RR 1.33), and neonatal asphyxia (RR 1.21) (11). Likewise, a 2024 investigation reported that anemia in the third trimester was linked to increased rates of cesarean birth, preterm labor, placental abruption, and neonatal intensive care unit admissions (12) Furthermore, a 2025 systematic review conducted in Egypt identified a 49% prevalence of anemia among pregnant women, with affected neonates exhibiting significantly lower birth weights and Apgar scores (13).

One of the primary strategies to prevent and control anemia among pregnant women is the provision of iron and folic acid supplementation (commonly referred to as iron tablets). In Indonesia, the coverage of iron tablet distribution has reached 92.2%. Nevertheless, only 44.2% of pregnant women consume the supplements in accordance with the recommended dosage and duration. Inadequate adherence to iron supplementation remains a significant factor contributing to the persistently high prevalence of maternal anemia. In addition, insufficient antenatal care (ANC) utilization plays an

important role in the occurrence of anemia during pregnancy. Although 86.7% of pregnant women attend the first antenatal visit (K1), only 17.6% complete the recommended six visits (K6). Disparities in the quality of maternal health services are also evident. Only 57.8% of pregnant women receive antenatal examinations that meet the comprehensive 10T service standard, and merely 2.7% participate in at least four sessions of maternal classes, including one session attended with a husband or family member. These gaps in service utilization and quality may hinder early detection and effective management of anemia during pregnancy (4).

Anemia in pregnancy remains a global public health concern. The World Health Organization estimates that anemia affects a substantial proportion of women of reproductive age and pregnant women worldwide, with consequences for maternal health, fetal growth, and neonatal outcomes (1). In Indonesia, anemia among pregnant women has persisted despite long-running antenatal care and iron-folic acid supplementation programs. The 2023 Indonesian Health Survey reported that approximately three in ten pregnant women experienced anemia, indicating that national prevention efforts still require strengthening and more precise targeting (4).

The topic is relevant to the scope of religion and public health because maternal health behaviors in Indonesia are embedded in family, community, and sociocultural systems, including faith-based and community networks that often influence health information, decision-making, food practices, and care-seeking behavior. Although SKI 2023 does not directly measure individual religiosity, the findings can inform community- and religiously engaged public health strategies to improve maternal nutrition, ANC attendance, and iron-folic acid adherence. The absence of direct religiosity variables is acknowledged as a limitation rather than overstated as an empirical finding.

Previous Indonesian studies have examined determinants of anemia in pregnancy using local samples or older national datasets. However, updated national evidence from SKI 2023 is needed, particularly evidence that simultaneously considers sociodemographic factors, chronic energy deficiency, ANC quantity, ANC quality based on 10T components, and iron-folic acid supplementation adherence using methods appropriate for complex survey data. This study therefore aimed to identify factors associated with anemia among pregnant women in Indonesia using design-based analysis of SKI 2023 data.

Methods

Study Design and Period

This study used an observational analytic cross-sectional design based on secondary analysis of Survei Kesehatan Indonesia (SKI) 2023 data. The manuscript was revised using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies as a reporting guide(14). Because exposure and outcome variables were measured at the same survey period, the analysis estimates associations and does not establish causal or temporal relationships.

Data Source and Study Population

The data source was SKI 2023, a nationally representative health survey conducted by the Ministry of Health of the Republic of Indonesia. The survey used a multistage complex sampling design. The study population comprised pregnant women recorded in the SKI 2023 maternal health module. The analysis included women who were pregnant at the time of the survey and had available hemoglobin measurements, mid-upper arm circumference (MUAC) measurements, and complete information for selected covariates.

Sample Size and Data Processing

After data merging, case selection, cleaning, and application of sampling weights to account for the complex survey design, the final weighted analytical sample represented 121,339 pregnant women at the population level. Data cleaning procedures involved excluding observations with missing values in key variables, particularly Chronic Energy Deficiency (CED) status and adherence to iron and folic acid supplementation. The inclusion criteria were as follows:1) Pregnant women with available hemoglobin examination data and MUAC measurement, 2) Pregnant women with complete information on all variables included in the analysis.

Variables

The dependent variable was anemia status, defined as hemoglobin concentration <11 g/dL among pregnant women, consistent with WHO criteria [1]. Independent variables were defined as follows:

1. Maternal age: age at risk was coded as <20 years or >35 years; not at risk was coded as 20-35 years.
2. Maternal education: low education was defined as no schooling, elementary school, or junior secondary school; high education was defined as senior secondary school or higher. The final coding should be verified against SKI education categories.
3. Maternal occupation: unemployed was defined as not being in paid employment at the time of survey, including housewives, students, and women not working; employed was defined as having paid work or income-generating occupation. This operational definition should be aligned with the exact SKI occupation categories.
4. Economic status: low economic status was defined using the lower household wealth categories/quintiles available in SKI, while high economic status represented middle to highest wealth categories. The exact cut-off must be reported according to the SKI wealth variable used.
5. ANC quantity: regular ANC was defined as at least six ANC visits during pregnancy, consistent with Indonesian maternal health service standards; irregular ANC was defined as fewer than six visits. Because some women may have been surveyed before reaching late pregnancy, this variable should be interpreted cautiously unless adjusted for gestational age.
6. ANC quality: complete ANC quality was defined as receiving the 10T antenatal service components according to national standards; incomplete ANC quality indicated that one or more 10T components were not documented. The exact 10T components available in SKI and included in the composite indicator must be listed in the final manuscript.
7. Chronic energy deficiency (CED): CED was defined as MUAC <23.5 cm.
8. Iron-folic acid supplementation adherence: adherence was defined as self-reported consumption of at least 90 iron-folic acid tablets during pregnancy. Non-adherence was defined as consumption of fewer than 90 tablets. Because this threshold may be less appropriate for women in early pregnancy, the result should be interpreted as cumulative intake status at the time of survey, not as completed-pregnancy adherence.

Complex Survey Design Variables

All analyses incorporated the complex survey design variables provided in the SKI 2023 microdata. The final sampling weight (w_final) was applied to account for unequal probabilities of selection, non-response, and post-stratification adjustment so that estimates represented the target population of pregnant women in Indonesia. The stratum variable (STRATA) was specified as the survey strata, and the primary sampling unit variable (PSU) was specified as the cluster identifier. These design variables were declared before conducting descriptive, bivariate, and multivariable analyses; therefore, all weighted percentages, odds ratios, confidence intervals, standard errors, and p-values were design-adjusted.

Statistical Analysis

Statistical analysis was performed using survey procedures appropriate for complex sample data. The survey design was specified by setting PSU as the cluster variable, STRATA as the stratification variable, and w_final as the sampling weight. Standard errors and 95% confidence intervals were estimated using Taylor series linearization, which accounts for clustering, stratification, and weighting in complex survey data. Weighted proportions were used to describe respondent characteristics and anemia prevalence (15). Bivariate associations between each independent variable and anemia status were assessed using design-adjusted Rao-Scott chi-square tests (16).

Crude odds ratios (ORs) and 95% confidence intervals were estimated using survey-weighted logistic regression. Multivariable logistic regression was then fitted using the same survey design specification to estimate adjusted odds ratios (AORs) and 95% confidence intervals for factors associated with anemia. Variables were selected based on conceptual relevance, previous evidence, and bivariate findings. Statistical significance was set at $p<0.05$, and all p-values were two-sided. Because the analysis was based on cross-sectional survey data, the adjusted odds ratios were interpreted as measures of association rather than causal effects.

Ethical Considerations

This study used anonymized secondary data obtained from the official Data Service Portal of the Indonesian Ministry of Health under document request number 2509E71F9CAE8424. No personal identifiers were available to the authors. The final manuscript should state whether the original SKI 2023 survey obtained ethical approval and informed consent according to the Ministry of Health survey protocol. Because this study involved secondary analysis of de-identified open-access data, additional institutional ethical review was not required according to the authors' institutional policy, if accepted by the journal. The data were obtained through the official Data Service Portal of the Indonesian Ministry of Health (https://layanandata.kemkes.go.id/)

Results

Univariat Analysis

The finding shown on table 1, that 28.2% of pregnant women were anemic aligns with other community-based studies in Indonesia, which report moderate to high anemia prevalence among pregnant populations, reflecting persistent nutritional and health service challenges. Although variations exist due to setting and measurement, studies consistently show anemia remains a significant issue associated with maternal factors and service utilization patterns (17).

Lower maternal education was observed in 28.8% of the sample and is a known determinant of both anemia and health behavior. Studies using national survey data in Southeast Asia and sub-Saharan Africa have shown that educational attainment significantly influences maternal health behaviors, including iron supplementation adherence and timely ANC attendance. For example, in Cambodia, pregnant women with primary or higher education had greater odds of adhering to iron supplementation compared with women without formal education (18). This supports the concept that education enhances health literacy, enabling pregnant women to better understand the importance of nutrition and preventive care.

The high proportion of unemployed women (75.7%) suggests economic vulnerability, which is frequently associated with limited access to nutrient-rich diets and healthcare services. Socioeconomic status is consistently linked to anemia risk in pregnancy; lower income and employment insecurity can lead to food insecurity and inadequate nutrient intake, which directly affects hemoglobin levels. Although not as extensively documented in global literature as other factors, multiple Indonesian studies emphasize the socioeconomic gradient in anemia prevalence among pregnant women (19).

Table 1. Characteristics of Pregnant Women (n = 121,339)

Variable	Category	Weighted n	Weighted %
Anemia status	Anemia	34,253	28.2
	Non-anemia	87,085	71.8
Age risk	At risk (<20 and >35 years)	19,851	16.4
	Not at risk (20-35 years)	101,487	83.6
Maternal education	Low	34,950	28.8
	High	86,388	71.2
Maternal occupation	Unemployed	91,826	75.7
	Employed	29,512	24.3
Economic status	Low	29,582	24.4
	High	91,756	75.6
ANC quantity	Irregular (< 6 visits)	15,156	12.5
	Regular (≥ 6 visits)	106,182	87.5
ANC quality (10T)	Incomplete	10,424	8.6
	Complete	110,914	91.4
Chronic Energy Deficiency (CED)	Yes	20,232	16.7
	No	101,106	83.3
Iron supplementation adherence	Non-adherent (<90 tablets)	71,847	59.2
	Adherent (≥90 tablets)	49,491	40.8

High levels of regular ANC attendance (87.5%) and complete ANC quality services (91.4%) reflect good access to maternal care, yet anemia persists. This suggests that coverage alone is not sufficient; the quality and comprehensiveness of counseling and service delivery during ANC are critical. Studies in Ethiopia have shown that frequent and early ANC visits improve adherence to iron and folic acid supplementation, which in turn can reduce anemia prevalence. For instance, women who attended ≥4 ANC visits were more likely to adhere to iron supplementation compared with women having fewer visit (18). This indicates that ANC visits may serve as platforms for education and reinforcement of health behaviors necessary to prevent anemia.

The presence of CED in 16.7% of women underscores the role of general maternal nutrition in anemia etiology. While specific international systematic reviews are limited in the last five years on CED and anemia, localized studies consistently report significant associations between undernutrition (e.g., low mid-upper arm circumference) and anemia in pregnancy. This reflects the multifactorial nature of anemia, where deficiencies beyond iron — including macronutrient insufficiencies — contribute to inadequate hemoglobin synthesis (20).

A critical finding in this study is that only 40.8% of women adhered to recommended iron and folic acid supplementation. Low adherence to iron supplementation is a well-recognized global challenge, as highlighted in a systematic review and meta-analysis of studies predominantly from low- and middle-income countries. This review documented that only about 46.2% adhered to supplementation regimens and identified that counseling, early antenatal registration, and good knowledge of supplementation significantly increased adherence (21). Similarly, studies in Ethiopia reported that maternal education, early timing of ANC, and good knowledge about iron-folate supplements were positively associated with supplementation adherence, reinforcing that behavioral factors strongly influence adherence beyond mere availability of supplements (18).

Non-adherence remains a key contributor to persistent maternal anemia, even in contexts with high ANC coverage. Barriers identified in global research include fear of side effects, lack of counseling,

limited understanding of the benefits, and forgetfulness — all of which reduce compliance to supplementation protocols (21).

Bivariat Analysis

Bivariate analysis from table 2, demonstrated that all examined variables were significantly associated with maternal anemia ($p < 0.001$). Pregnant women categorized as age-at-risk had a higher prevalence of anemia (36.4%) compared with those not at risk (26.6%), with a crude odds ratio (OR) of 1.58 (95% CI: 1.53–1.63). Women with low education had slightly higher anemia prevalence than those with higher education (29.9% vs. 27.6%; OR = 1.12; 95% CI: 1.09–1.15).

Table 2. Bivariate Analysis of Factors Associated with Maternal Anemia

Variable	Comparison Category	Weighted % Anemia	Crude OR (95% CI)	p-value
Age risk	At risk vs not	36.4% vs 26.6%	1.58 (1.53–1.63)	<0.001
Maternal Education	Low vs high	29.9% vs 27.6%	1.12 (1.09–1.15)	<0.001
Maternal Occupation	Unemployed vs employed	31.7% vs 17.4%	2.20 (2.13–2.27)	<0.001
Economic status	Low vs high	30.7% vs 27.4%	1.18 (1.14–1.21)	<0.001
ANC quantity	Irregular vs regular	32.9% vs 27.6%	1.29 (1.25–1.34)	<0.001
ANC quality (10T)	Incomplete vs complete	15.5% vs 29.4%	0.44 (0.42–0.47)	<0.001
Chronic Energy Deficiency (CED)	Yes vs no	32.4% vs 27.4%	1.27 (1.23–1.31)	<0.001
Iron supplementation adherence	Non-adherent vs adherent	30.6% vs 24.8%	1.33 (1.30–1.37)	<0.001

Maternal employment status showed a strong association, where unemployed women were more than twice as likely to be anemic compared to employed women (31.7% vs. 17.4%; OR = 2.20; 95% CI: 2.13–2.27). Similarly, women with low economic status had higher anemia prevalence (30.7% vs. 27.4%; OR = 1.18; 95% CI: 1.14–1.21).

Health service utilization was also significantly associated with anemia. Women with irregular antenatal care (ANC) visits had higher anemia prevalence (32.9% vs. 27.6%; OR = 1.29; 95% CI: 1.25–1.34). Interestingly, women receiving complete ANC services (10T standard) showed higher anemia prevalence (29.4%) compared with those with incomplete services (15.5%; OR = 0.44; 95% CI: 0.42–0.47), possibly reflecting improved detection through comprehensive screening.

Women with Chronic Energy Deficiency (CED) had higher anemia prevalence (32.4% vs. 27.4%; OR = 1.27; 95% CI: 1.23–1.31). Furthermore, non-adherence to iron supplementation was significantly associated with anemia (30.6% vs. 24.8%; OR = 1.33; 95% CI: 1.30–1.37).

Multivariat Analysis

The multivariate logistic regression analysis demonstrates that several sociodemographic and service-related factors independently predict anemia among pregnant women after adjustment for confounders. All variables included in the model were statistically significant ($p < 0.001$), indicating robust associations with anemia status.

Maternal age classified as “at risk” was associated with a 1.69-fold increase in the likelihood of anemia compared to non-risk age groups (AOR = 1.69; 95% CI: 1.63–1.74). This finding suggests that pregnancies occurring at biologically vulnerable ages—such as adolescence or advanced maternal age—are significantly more susceptible to compromised hemoglobin status. Physiologically, these

age groups often experience higher nutritional demands or reduced adaptive capacity to the hematologic changes of pregnancy.

Table 3. Multivariate Logistic Regression Analysis of Predictors of Maternal Anemia

Variable	Category	Adjusted OR (AOR)	95% CI	p-value
Age risk	Age at risk (<20 and >35 years)	1.69	1.63–1.74	<0.001
Maternal Education	Low education	0.82	0.80–0.84	<0.001
Maternal Occupation	Unemployed	2.46	2.38–2.55	<0.001
ANC quantity	Irregular ANC visits (< 6 visits)	1.41	1.36–1.47	<0.001
ANC quality (10T)	Incomplete ANC quality (10T)	0.34	0.32–0.36	<0.001
Chronic Energy Deficiency (CED)	Chronic Energy Deficiency (CED)	1.28	1.24–1.33	<0.001
Iron supplementation adherence	Non-adherence (<90 tablets)	1.44	1.40–1.48	<0.001

Maternal education showed a protective association. Women with lower education had an adjusted odds ratio of 0.82 (95% CI: 0.80–0.84), indicating a statistically significant relationship in the model. Although the direction suggests lower odds compared to the reference category, this result should be interpreted in light of coding and reference group designation. Education likely influences anemia indirectly through health literacy, nutritional awareness, and healthcare utilization behaviors.

Maternal occupation emerged as the strongest predictor in the model. Unemployed pregnant women had 2.46 times higher odds of experiencing anemia compared to employed women (AOR = 2.46; 95% CI: 2.38–2.55). This is the highest adjusted odds ratio among all variables, indicating that employment status is the most dominant determinant in this analysis. Employment may reflect economic autonomy, improved access to nutritious foods, greater exposure to health information, and enhanced healthcare utilization. Conversely, unemployment may be associated with economic dependency and limited access to preventive resources, thereby increasing vulnerability to anemia.

Regarding antenatal care, irregular ANC (≥ 6 times) visits significantly increased the risk of anemia by 41% (AOR = 1.41; 95% CI: 1.36–1.47). This underscores the importance of consistent ANC attendance for early screening, monitoring hemoglobin levels, and reinforcing iron supplementation adherence. The adjusted odds ratio for ANC quality was 0.34 (95% CI: 0.32–0.36), indicating a statistically significant protective association. However, because the protective direction appears inconsistent with the label “incomplete ANC quality,” this finding should be interpreted cautiously. It is necessary to verify the reference category and coding of the ANC variable. Conceptually, complete and high-quality ANC is expected to reduce anemia risk through comprehensive screening, counseling, iron–folic acid supplementation, and nutritional interventions.

Chronic Energy Deficiency (CED) was significantly associated with anemia (AOR = 1.28; 95% CI: 1.24–1.33), indicating that undernourished women are more vulnerable to reduced hemoglobin levels. This relationship is biologically plausible, as long-term inadequate energy and nutrient intake diminishes iron reserves and impairs erythropoiesis.

Non-adherence to iron supplementation increased the odds of anemia by 44% (AOR = 1.44; 95% CI: 1.40–1.48), reinforcing the central role of iron–folic acid supplementation in preventing gestational anemia. Regular supplementation directly addresses iron deficiency, the primary cause of anemia during pregnancy.

Based on the magnitude of the adjusted odds ratios, maternal occupation (unemployment) is the most

dominant predictor of anemia in this model (AOR = 2.46). This indicates that socioeconomic vulnerability, as reflected by employment status, exerts the strongest independent influence on anemia risk among pregnant women. The dominance of occupation suggests that structural determinants—particularly economic empowerment—play a more substantial role than biological or service-utilization factors alone.

Therefore, interventions aimed at reducing maternal anemia should not only focus on clinical measures such as iron supplementation and ANC quality but also incorporate socioeconomic strengthening strategies, including women's economic empowerment, social protection programs, and improved access to income-generating opportunities.

Discussion

This study provides updated national evidence on factors associated with anemia among pregnant women in Indonesia using SKI 2023. The weighted anemia prevalence of 28.2% is consistent with recent national reporting that anemia remains an important maternal health problem in Indonesia. Because the study is cross-sectional, the findings should be interpreted as associations rather than causal effects.

Age Maternal

The higher anemia prevalence among age-at-risk mothers aligns with global evidence that adolescent and advanced maternal age increase anemia risk due to higher physiological iron demands and nutritional vulnerability. A 2023 systematic review published in *Scientific Reports* identified maternal age as a consistent determinant of anemia among women of reproductive age across (22)

Maternal age has been widely recognized as a significant demographic factor influencing the risk of anemia during pregnancy. Several local studies in Indonesia have shown a statistically significant relationship between maternal age and the occurrence of anemia; for example, research conducted at a community health facility found that women categorized as being at *high-risk ages* (commonly defined as adolescents under 20 years or older than 35 years) had a significantly higher incidence of anemia compared to women in low-risk age groups ($p < 0.05$) . Biologically, this association can be attributed to the physiological and nutritional demands at the extremes of reproductive age: adolescents are still completing their own growth and have higher iron requirements, while older women may have accumulated nutritional deficiencies and chronic health conditions that impair hematologic adaptation to pregnancy (23).

Global evidence supports this link through comprehensive reviews and epidemiological analyses showing that maternal age influences anemia prevalence in pregnancy. A systematic overview of determinants of women's anemia in low- and middle-income countries highlighted maternal age as one of the sociodemographic factors connected with persistent anemia, where both younger and older maternal ages were associated with inadequate hemoglobin levels due to nutritional, reproductive, and care-seeking disparities . These findings underscore the need for age-targeted antenatal nutrition education, screening, and supplementation strategies to mitigate anemia risk in vulnerable age groups (24).

High-risk maternal age associated with anemia. This is biologically and socially plausible because adolescent pregnancy and pregnancy at older maternal age can involve different nutritional demands, reproductive histories, and care-seeking patterns. This finding supports age-sensitive ANC counseling and earlier nutrition screening for vulnerable groups.

Maternal Education

Low maternal education and poor socioeconomic conditions were significantly associated with

anemia in this study. Education influences health literacy, dietary diversity, and supplement adherence. A 2022 systematic review and meta-analysis found that low educational status significantly increased the likelihood of maternal anemia in low- and middle-income countries (11). Similarly, socioeconomic disadvantage has been widely documented as a structural determinant of maternal anemia due to limited access to iron-rich foods and health services. An analysis demonstrated strong wealth-related inequalities in anemia prevalence among women of reproductive age (25)

Educational attainment of pregnant women has been consistently linked to anemia risk in numerous studies, including research in Indonesian populations. Education influences a woman's knowledge, attitudes, and practices regarding nutrition, iron supplementation, and utilization of maternal health services. A cross-sectional study reported that low maternal education was significantly associated with anemia in pregnant women, suggesting that women with less formal education had higher odds of anemia compared to more educated counterparts. Education enhances health literacy, enabling women to understand the importance of iron-rich diets, adherence to supplementation, and early health-seeking behavior, which are critical for preventing iron deficiency anemia during pregnancy (24).

The global literature also supports this association: a meta-analysis of risk factors across diverse settings identified low maternal education as a significant distal determinant of anemia in pregnancy, likely through its influence on both nutrition and healthcare use . Educated women are more likely to access and act upon health information, comply with antenatal care recommendations, and adopt dietary practices that increase iron intake. As a result, educational interventions—especially those tailored to women with limited schooling—are essential components of anemia prevention programs within ANC and community health frameworks (24).

Maternal Occupation

Based on other study (26), Pregnant women who were employed had a 1.34-fold lower risk of anemia compared to those who were not employed. In this study, employment was categorized as involving a moderate workload, whereas non-employment was classified as a light workload. Pregnant women in the light workload category were more likely to experience anemia compared to those engaged in moderate workload occupations. Employment during pregnancy may indicate that women have their own source of income, which can contribute to supporting household needs alongside their husbands. Having an income is associated with improved financial capacity, which in turn enhances access to health information, including knowledge about anemia. Adequate household finances may facilitate better nutrition, access to health services, and the ability to obtain preventive measures, thereby reducing the risk of anemia among pregnant women (26).

Maternal occupation reflects not only labor force participation but also socioeconomic position and autonomy, which relate indirectly to nutritional status and anemia risk. In Indonesian settings, the relationship between occupation and anemia has shown mixed results in small community studies; however, broader analyses incorporate occupation as part of the sociodemographic profile influencing anemia. Socioeconomic reviews have found that employment status and income generation empower women with greater financial resources to purchase nutritious foods, access healthcare services, and maintain healthier lifestyles, thereby reducing anemia risk. While a specific study did not find a direct relationship between employment status and adherence to iron tablet, the broader evidence suggests that occupation interacts with other determinants. For example, employed women may have better access to information, health insurance, and regular ANC visits, all of which contribute to lower anemia prevalence (27).

Additionally, systematic reviews of anemia determinants in pregnancy include socioeconomic and labor variables as part of the structural drivers affecting anemia risk. Although occupation itself may

not always show a direct statistical association in every setting, it is related to household income, food security, and health service utilization—all of which are established contributors to anemia in pregnancy . Therefore, public health strategies should consider employment support and economic empowerment for women as part of multifaceted efforts to reduce anemia prevalence in pregnancy (24).

Economic Status

Economic factors represent a key social determinant influencing the occurrence of anemia among pregnant women. Household economic status affects a woman's ability to access nutritious foods, quality health services, and essential micronutrient supplementation during pregnancy. Low socioeconomic status is frequently associated with limited purchasing power, restricting access to iron-rich foods and other vital nutrients. Consequently, pregnant women from economically disadvantaged households are at greater risk of iron deficiency and subsequent anemia. Global epidemiological analyses consistently identify low income as a major determinant of maternal anemia across low- and middle-income countries. For instance, national survey data from Egypt have demonstrated that inadequate iron intake and low socioeconomic status are significant risk factors for anemia during pregnancy (28)

In addition, studies examining social determinants in the context of adherence to iron supplementation have demonstrated that economic inequality directly influences the likelihood of meeting adequate daily iron intake. Women from lower socioeconomic groups are more likely to experience limited access to antenatal care services, iron–folic acid supplementation, and health education programs that support anemia prevention. Conceptually, the inability to obtain a balanced diet and adequate supplementation constitutes a direct barrier to achieving optimal hematologic status during pregnancy, thereby increasing vulnerability to iron deficiency and anemia (29).

The result suggests that socioeconomic position is an important marker for identifying pregnant women who may require more intensive nutritional and service support.

ANC Quantity

Regular ANC attendance was protective against anemia. ANC provides a platform for screening, iron supplementation, and counseling. A 2020 systematic review in *Reproductive Health* found that women who attended four or more ANC visits were significantly more likely to adhere to iron supplementation and less likely to develop anemia (21). The finding that complete ANC quality was associated with higher recorded anemia prevalence may reflect improved detection rather than increased risk. Enhanced screening practices can increase reported prevalence due to better case identification.

Frequency of antenatal care (ANC) visits is a critical indicator in the prevention and early detection of anemia during pregnancy. National studies in Indonesia (30) have reported that pregnancies with ANC visits meeting the recommended standard (e.g., ≥6 visits throughout pregnancy) are significantly associated with lower anemia prevalence. Evidence from primary healthcare settings indicates that pregnant women who attended ANC according to national standards had significantly lower rates of anemia compared to those with suboptimal visit frequency. Routine ANC monitoring enables healthcare providers to identify women at high risk of anemia and implement timely interventions, including nutritional counseling, periodic hemoglobin assessment, and appropriate iron supplementation (30).

Regular ANC attendance also enhances access to other preventive services. Studies conducted in Indonesian primary health centers demonstrate that consistent visits facilitate continuous iron–folic acid supplementation and timely health education, thereby reducing anemia risk. Beyond visit frequency, these findings emphasize the importance of periodic hemoglobin monitoring, which is

more likely to be conducted when pregnant women adhere to scheduled ANC appointments. Continuous clinical follow-up allows healthcare providers to track hematological status and adjust supplementation strategies accordingly (31).

International evidence further supports the association between adequate ANC utilization and reduced anemia risk. Global literature analyses indicate that regular ANC visits create structured opportunities for anemia screening, provision of iron and folic acid supplements, and delivery of nutrition counseling—key preventive measures during pregnancy. Systematic reviews have shown that inadequate or delayed ANC increases the risk of anemia by missing critical windows for early nutritional intervention, particularly during the first and second trimesters. Observational studies in low- and middle-income countries consistently demonstrate that women with fewer ANC visits are more likely to experience iron deficiency and anemia compared to those receiving care aligned with health recommendations. Continuous antenatal monitoring enables early identification of nutritional deficiencies and facilitates comprehensive interventions, including supplementation, dietary counseling, and referral when necessary, collectively contributing to reduced anemia incidence during pregnancy (31)

Irregular ANC visits and non-adherence to iron-folic acid supplementation were associated with anemia. ANC is a key platform for hemoglobin screening, nutrition counseling, iron-folic acid distribution, management of side effects, and reinforcement of adherence. Nevertheless, the use of a fixed threshold of six ANC visits or 90 tablets may be affected by gestational age at the time of survey. Women in early pregnancy may not yet have had sufficient time to complete six ANC visits or consume 90 tablets. Future analysis should adjust these indicators for gestational age when possible

ANC Quality

High-quality antenatal care (ANC) is a critical strategy for preventing anemia in pregnancy. The 10T ANC framework refers to a standardized antenatal service package that includes comprehensive clinical examinations, nutritional education, regular pregnancy monitoring, and guideline-based supplementation. Optimal ANC utilization encompasses not only the recommended number of visits but also the quality of care delivered. Quality ANC provides repeated opportunities for anemia screening, appropriate management of iron–folic acid supplementation, continuous nutritional counseling, and timely clinical interventions, thereby strengthening efforts to prevent and control maternal anemia(32)

Cross-national evidence indicates that adequate engagement in antenatal care (ANC) is positively associated with higher adherence to iron supplementation, a core component of the 10T antenatal service standard. For instance, a multi-country analysis across 12 low- and middle-income countries demonstrated that receiving at least four ANC visits significantly increased the likelihood of consuming ≥90 iron–folic acid tablets during pregnancy, which in turn contributed to a reduced risk of maternal anemia. These findings suggest that ANC quality influences anemia outcomes primarily through improved adherence to iron supplementation and reinforced education on appropriate maternal nutrition. Quality of care also encompasses the capacity of health providers to identify anemia risk early and implement timely interventions, including dietary counseling, management of supplementation-related side effects, and continuous follow-up. High-standard antenatal services create repeated opportunities for effective nutritional intervention and early detection of complications, which collectively contribute to lowering the prevalence of anemia among pregnant women (32).

Chronic Energy Deficiency (CED)

Chronic Energy Deficiency (CED) in pregnant women reflects prolonged undernutrition, encompassing inadequate energy intake and deficiencies in essential micronutrients, including iron.

CED adversely affects maternal metabolism and impairs hemoglobin synthesis due to depleted energy reserves and insufficient micronutrient stores. Women with CED often enter pregnancy with already compromised iron reserves; therefore, when iron requirements substantially increase during the second and third trimesters, the body is unable to meet the heightened hematopoietic demand, leading to an elevated risk of anemia (33).

Although recent international literature specifically linking CED and anemia remains limited, evidence from developing countries and national survey-based reports consistently associates poor maternal nutritional status with low hemoglobin levels through sustained nutrient deficiencies. Retrospective studies further indicate that the coexistence of CED and anemia increases the risk of adverse pregnancy outcomes, such as low birth weight, indirectly reinforcing the close relationship between maternal energy–nutritional status and anemia during pregnancy (33).

Physiologically, chronic energy deficiency reduces the body's capacity to store and mobilize iron, impairs nutrient absorption, and heightens susceptibility to infections, all of which can exacerbate hematological deterioration. Collectively, these mechanisms explain why pregnant women with CED face a substantially higher likelihood of developing anemia (33).

CED was associated with anemia, supporting the concept that anemia prevention should not focus only on iron tablets but also on broader maternal nutrition. MUAC <23.5 cm indicates chronic undernutrition, which may reduce iron stores, impair erythropoiesis, and increase susceptibility to anemia. Integrated ANC should therefore combine supplementation, dietary counseling, and identification of women with poor nutritional status.

Iron supplementation adherence

Adherence to iron–folic acid supplementation (commonly referred to as tablet tambah darah/TTD) is a well-established and evidence-based strategy for preventing anemia during pregnancy. Studies across diverse settings consistently demonstrate that pregnant women who adhere to the recommended dosage—at least ≥90 tablets throughout pregnancy—exhibit significantly higher hemoglobin levels compared with non-adherent women, with statistically meaningful differences in hematological outcomes (23).

Non-adherence to TTD has direct implications for maternal hemoglobin status, as inadequate iron intake fails to meet the increased physiological demands of pregnancy. Cross-sectional studies conducted in multiple healthcare facilities in Indonesia have identified a significant association between poor adherence to TTD and higher incidence of anemia; pregnant women who do not comply with supplementation recommendations are considerably more likely to develop anemia than those who adhere to the prescribed regimen (34).

Adherence behavior is multifactorial, influenced by maternal knowledge about anemia, family support, perceived side effects, and individual motivation. Effective health education, supportive counseling, and strengthened antenatal care services play a critical role in improving compliance, which ultimately contributes to reducing the prevalence of anemia among pregnant women (34)

Religious, Community, and Sociocultural Context in Maternal Anemia Prevention

The findings of this study indicate that anemia among pregnant women is associated with socioeconomic factors, antenatal care utilization, nutritional status, and adherence to iron–folic acid supplementation. These findings suggest that anemia prevention should not rely solely on the distribution of iron–folic acid tablets, but should also consider health behavior, family support, and the broader social context in which pregnant women live. Low adherence to iron–folic acid supplementation may be influenced by limited maternal understanding, perceived side effects, forgetfulness, and insufficient support from family members and the surrounding community (21,35).

In religious and communal societies, religious leaders, community health workers, and faith-based

organizations may serve as important bridges between formal health messages and community acceptance. Religious leaders often hold trusted social positions and may help reinforce maternal health messages, particularly regarding the importance of maintaining health during pregnancy, taking iron–folic acid tablets regularly, attending antenatal care, and involving husbands and family members in supporting pregnant women. This approach is not intended to replace formal health services, but rather to strengthen health promotion through social channels that are familiar and trusted by the community (36).

The involvement of faith-based communities is also relevant to the findings on maternal occupation and socioeconomic status. Pregnant women who are unemployed or from economically vulnerable groups may require not only clinical support, but also social and community-based support. Community platforms, including women's religious study groups, faith-based women's organizations, and local religious gatherings, may be utilized as culturally acceptable settings for maternal health education. Education on anemia, pregnancy nutrition, and adherence to iron–folic acid supplementation can be integrated into community activities, while still being guided by scientific evidence and recommendations from health professionals (36,37).

Therefore, the policy implication of this study is the need to strengthen collaboration among primary health care centers, midwives, community health workers, families, and religious leaders in preventing maternal anemia. Antenatal care programs should not only function as clinical services, but also as entry points for culturally sensitive and community-based interventions. Such strategies may improve maternal health literacy, strengthen social support, and promote sustainable behavioral change in the prevention of anemia among pregnant women. Nevertheless, because religiosity was not directly measured in this study, the role of religious and faith-based communities should be interpreted as a contextual implication for health promotion and policy development rather than as a direct statistical finding.

Strenght and Limitation Study

The major strength of this study is the use of recent national survey data, allowing assessment of maternal anemia using a large population-based dataset. The analysis also examined biological, socioeconomic, nutritional, ANC-related, and supplementation-related variables, providing a multidimensional view of anemia in pregnancy.

This study has several limitations. First, the cross-sectional design prevents causal inference and temporal ordering. Second, some indicators, such as ANC quantity and iron-folic acid adherence, may be influenced by gestational age at survey. Third, self-reported tablet consumption may be affected by recall or social desirability bias. Fourth, the analysis could not fully account for dietary intake, infection, inflammation, parasitic disease, genetic hemoglobin disorders, or detailed household food security. Fifth, unexpected inverse associations for low education and incomplete ANC quality require coding verification and sensitivity analysis before final interpretation.

Conclusion

Maternal anemia among pregnant women in Indonesia is associated with maternal age, occupation, ANC utilization, nutritional status, and iron-folic acid supplementation adherence. The findings support strengthening integrated ANC services, improving counseling and follow-up for iron-folic acid adherence, identifying women with CED, and prioritizing economically vulnerable pregnant women. Results related to education and ANC quality should be interpreted cautiously and verified through coding checks and sensitivity analyses. Future studies should use longitudinal designs and include gestational age, dietary intake, infection, inflammation, and sociocultural or religiosity-related variables to better understand pathways to maternal anemia.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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