Iron intake and anemia as predictors of preeclampsia risk in pregnant women in the second trimester

Asupan zat besi dan anemia sebagai predictor risiko preeklampsia pada ibu hamil trimester kedua

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Abstract

Preeclampsia remains one of the leading causes of maternal morbidity and mortality worldwide, including in Indonesia. Iron deficiency anemia is considered a modifiable risk factor; however, few studies have specifically examined the relationship between anemia status and iron intake and the risk of preeclampsia during the second trimester of pregnancy. This study aimed to analyze the relationship between anemia status and iron intake and the risk of preeclampsia among second-trimester pregnant women. A cross-sectional analytical design was employed involving 150 pregnant women selected through purposive sampling in the working area of Pattallassang Public Health Center, Takalar Regency, between January and March 2025. Data were collected through hemoglobin level examination, a *Food Frequency Questionnaire* (FFQ) for iron intake assessment, and medical records for preeclampsia diagnosis. Data were analyzed using chi-square and logistic regression tests to determine the associations and predictive strength. The results showed that 30% of respondents experienced preeclampsia, 42% had anemia, and 64% had an inadequate iron intake. Anemia and inadequate iron intake were significantly associated with an increased risk of preeclampsia ($p < 0.05$). In conclusion, anemia and iron intake are important predictors of preeclampsia risk, highlighting the need for nutritional screening and early intervention to prevent further complications.

Keywords: Anemia, Pregnant Women, Preeclampsia, Second Trimester, Iron

Abstrak

Preeklampsia merupakan salah satu penyebab utama morbiditas dan mortalitas pada ibu hamil di berbagai negara, termasuk Indonesia. Anemia defisiensi zat besi diduga menjadi faktor risiko yang dapat dimodifikasi, namun penelitian yang menelaah hubungan antara status anemia dan asupan zat besi dengan risiko preeklampsia pada trimester kedua masih terbatas. Penelitian ini bertujuan menganalisis hubungan status anemia dan asupan zat besi dengan risiko preeklampsia pada ibu hamil trimester kedua. Penelitian menggunakan desain analitik potong lintang pada 150 ibu hamil yang dipilih melalui purposive sampling di wilayah kerja Puskesmas Pattallassang, Kabupaten Takalar, pada Januari–Maret 2025. Data diperoleh melalui pemeriksaan kadar hemoglobin, kuesioner *Food Frequency Questionnaire* (FFQ), dan rekam medis diagnosis preeklampsia. Analisis dilakukan menggunakan uji chi-square dan regresi logistik untuk menentukan hubungan dan kekuatan prediktor. Hasil menunjukkan bahwa 30% responden mengalami preeklampsia, 42% anemia, dan 64% memiliki asupan zat besi tidak

adekuat. Status anemia dan asupan zat besi rendah berhubungan signifikan dengan peningkatan risiko preeklampsia ($p < 0.05$). Kesimpulannya, anemia dan asupan zat besi merupakan prediktor penting terhadap risiko preeklampsia, sehingga diperlukan skrining nutrisi dan intervensi dini guna mencegah komplikasi lebih lanjut.

Kata Kunci: Anemia, Ibu Hamil, Preeklampsia, Trimester Kedua, Zat Besi

Introduction

Preeclampsia remains one of the leading causes of maternal morbidity and mortality worldwide, including in the United States and Indonesia (Ahmed et al., 2023). This condition is characterized by elevated blood pressure accompanied by proteinuria occurring after 20 weeks of gestation and may progress to severe complications, such as eclampsia, HELLP syndrome, renal failure, and even maternal and fetal death (Iswardani et al., 2019). According to the World Health Organization (WHO), approximately 10% of pregnancies worldwide are affected by preeclampsia, with the highest maternal mortality rates found in developing countries (Kario et al., 2024). According to the 2018 Basic Health Research (Kemenkes, 2018) data, hypertensive disorders during pregnancy, including preeclampsia, are the second leading cause of maternal death, accounting for 25% of all cases. This indicates that preeclampsia continues to be inadequately managed despite the implementation of various intervention programs at the primary to tertiary healthcare levels (Kario et al., 2024). These figures emphasize the importance of identifying and controlling modifiable risk factors (Callahan et al., 2023).

One risk factor that has gained increasing attention in recent years is the nutritional status of pregnant women, particularly regarding iron-deficiency anemia. Anemia is a common health problem during pregnancy and is defined as a hemoglobin level of less than 11 g/dL. In Indonesia, most cases of anemia during pregnancy are attributed to iron deficiency, which may result from insufficient dietary intake, increased physiological demand during pregnancy, or poor adherence to iron supplementation (Ministry of Health RI, 2020).

Anemia during pregnancy has been linked to various obstetric complications, including preeclampsia, preterm labor, low birth weight (LBW), and perinatal mortality (Yusuf et al., 2023). Several studies have indicated that hypoxia resulting from anemia can stimulate the release of vasoconstrictive substances and increase oxidative stress, both of which contribute to endothelial dysfunction and the likelihood of preeclampsia (Dey et al., 2025).

In addition to anemia, adequate iron intake during pregnancy is crucial for maintaining maternal and fetal physiological balance (Umiastuti et al., 2024). Iron deficiency can impair hemoglobin synthesis, hinder placental development, and disrupt the balance between prostacyclin and thromboxane, contributing to elevated blood pressure and proteinuria, which are the two hallmark symptoms of preeclampsia (Nanda & Semarawisma, 2021). Therefore, monitoring both iron intake and anemia status is a fundamental component of antenatal care (Ahmed et al., 2023).

In Indonesia, the prevalence of anemia among pregnant women is high. According to Riskesdas (2018), nearly half (48.9%) of pregnant women are anemic, while the incidence of preeclampsia continues to increase, particularly during the second and third trimesters (Alfiana et al., 2024). This suggests a potential link between anemia and preeclampsia that has yet to be fully understood, especially in regions with limited healthcare access and services (Mohebi et al., 2018).

A significant gap in the literature is the lack of studies that explicitly examine the relationship between anemia, iron intake, and the incidence of preeclampsia, particularly during the second trimester of pregnancy (Bangsa et al., 2021). The trimester is a critical phase of placental development and maternal physiological adaptation (Lewandowska et al., 2019). Disruptions during this period may result in impaired vascular remodeling and an increased risk of preeclampsia (Callahan et al., 2023).

Moreover, promotive and preventive measures in antenatal care have not been fully integrated across all regions (Alfiana et al., 2024). The distribution of iron and folic acid (IFA) tablets is often not accompanied by a proper evaluation of anemia status or an

objective assessment of dietary iron adequacy (Callahan et al., 2023). This disconnect between policy and field implementation hinders the early detection of preeclampsia risk, which can be mitigated through timely interventions (Al-Bayyari et al., 2024).

This study is relevant because it combines two key approaches: objective assessment of anemia status through hemoglobin levels and analysis of dietary iron intake using the Food Frequency Questionnaire (FFQ) method (Dehghani et al., 2024). This integration provides a more comprehensive evaluation of the potential relationship between micronutrient intake and the risk of preeclampsia, particularly in pregnant women in the second trimester, who often receive less clinical attention than those in the third trimester (Apriyanti et al., 2023).

The high burden of high-risk pregnancies and limited maternal nutrition services in Pattallassang, Gowa Regency, underscores the urgency of addressing anemia and preeclampsia in pregnant women. As a locally underexplored area, the findings of this study may contribute valuable evidence to national and global maternal health research. By examining the relationship between anemia status and iron intake and the risk of preeclampsia, this study aims to strengthen scientific understanding and inform WHO-aligned strategies for reducing preventable maternal morbidity. The results are expected to support targeted nutritional interventions, early screening, and improved antenatal policies for preventing preeclampsia using nutrition-based approaches.

Methods

Design
This quantitative study used a cross-sectional design to analyze the relationship between anemia status, iron intake, and preeclampsia risk among second-trimester pregnant women. This design was selected to assess the relationship between variables at a single point in time without any intervention.

Study Setting and Period
This study was conducted in the service area of the Pattallasang Community Health Center and several midwifery practices (BPS) in Takalar Regency, South Sulawesi, Indonesia, from January to April 2025.

Population and Sample
The study population included all second-trimester pregnant women (13–27 weeks' gestation) who attended antenatal care (ANC) visits within the research setting. Purposive sampling was used based on predetermined inclusion and exclusion criteria.

The sample size in this study was determined using Slovin's formula, where n represents the required sample size, N the total population, and e the margin of error. With a total population of 250 women in their second trimester ($N = 250$) and a margin of error of 5% ($e = 0.05$). The sample size was determined using Slovin's formula, which resulted in a total of 150 respondents. Participants were selected based on specific inclusion and exclusion criteria. The inclusion criteria were as follows: pregnant women in the second trimester of gestation (13–27 weeks), who expressed willingness to participate by signing informed consent, had no history of chronic illnesses such as diabetes mellitus, chronic hypertension, or kidney disease, and possessed complete medical records, particularly those containing information on hemoglobin levels and blood pressure. Conversely, pregnant women experiencing bleeding or other pregnancy complications, those consuming non-iron supplements that could interfere with hemoglobin or blood pressure levels, and those with incomplete questionnaire responses were excluded from the study.

Data Collection
This study employed both independent and dependent variables. The independent variables included anemia status, defined as hemoglobin levels below 11 g/dL, and dietary iron intake, assessed using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). The dependent variable was the risk of preeclampsia, operationally defined as the presence of systolic blood pressure equal to or greater than 140 mmHg and/or diastolic blood pressure equal to or greater than 90 mmHg, accompanied by proteinuria.

Data were collected using several approaches. First, direct interviews were conducted using a structured questionnaire designed to evaluate the respondents' daily iron intake. Second, blood pressure measurements and proteinuria assessments were performed by

certified midwives or qualified healthcare professionals to ensure reliability. Finally, hemoglobin levels were obtained from existing laboratory records from the respondents' most recent antenatal care (ANC) visit.

Data Analysis

All collected data were analyzed using SPSS version 26.0. The analysis was conducted in three stages. Univariate analysis was employed to describe the distribution and characteristics of the respondents, including sociodemographic factors, anemia status, and iron intake levels. This was followed by a bivariate analysis using the chi-square (χ^2) test to determine the statistical relationship between anemia status, iron intake, and preeclampsia risk.

To further strengthen the findings, multivariate logistic regression analysis was performed to evaluate the joint predictive capacity of the independent variables in explaining the risk of preeclampsia among the study population.

Research Ethics

This study has been approved by the Ethics Committee of H. Padjonga Dg Ngalle Takalar Regional General Hospital (Number: 013/KEPK-RSUD/III/2025. Written consent was obtained from all participants, and confidentiality and the right to withdraw from the study at any time were guaranteed.

Result and Discussion

This study involved 150 pregnant women in the second trimester within the service area of the Pattallassang Community Health Center in Takalar Regency. The following presents the findings of the univariate and bivariate analyses.

Table 1. Characteristics of pregnant women

Characteristics	Category	n	%
Age (years)	< 20	12	8
	20 – 35	112	74.7
	> 35	26	17.3
Education	Elementary School	18	12
	Junior High School	40	26.7
	Senior High School	65	43.3
	University	27	18
Occupation	Housewife	85	56.7
	Private Employee	45	30
	Civil Servant	20	13.3
Body Weight (kg)	Mean ± SD	58.2 ± 6.5	–
Height (cm)	Mean ± SD	156.4 ± 5.2	–
Hemoglobin (g/dL)	Mean ± SD	10.8 ± 1.1	–
Iron Intake	Adequate	54	36
	Inadequate	96	64

Table 1 presents the demographic and clinical characteristics of the participants. The findings indicate that most pregnant women were within the optimal reproductive age group of 20–35 years (74.7%). This result aligns with the study by Khan et al. (2022), who found that pregnancies within this age range are generally associated with a lower incidence of complications than those among younger (<20 years) or older (>35 years) mothers. However, the 25.3% of women outside this range still represents a clinically important subgroup, as both adolescent and advanced maternal ages are significantly associated with maternal morbidity, preterm birth, and hypertensive disorders in pregnancy. This suggests that early identification and close monitoring of pregnancies in these age groups should be prioritized in antenatal programs in the future.

In terms of education level, the majority of respondents had at least a secondary education (70.0%), which likely contributed to better maternal health awareness and nutritional practices during pregnancy. Previous evidence by Abdullah et al. (2021) found that higher educational attainment enhances health literacy, resulting in a reduced prevalence of anemia. Conversely, 12.0% of women with only elementary education remained at higher risk for poor nutritional knowledge and inadequate antenatal care utilization, reinforcing the need for targeted education and counseling interventions.

Regarding occupation, more than half of the participants were housewives (56.7%), reflecting limited economic autonomy that may restrict access to diverse and nutrient-rich diets. Rahman et al. (2020) similarly reported that unemployed or economically dependent women had higher rates of nutritional deficiencies. This emphasizes the importance of integrating

socioeconomic empowerment and food security strategies into maternal health policies to address these nutritional disparities.

The mean hemoglobin (Hb) level of 10.8 g/dL indicates that anemia remains a substantial public health concern in the study population. This finding corroborates the WHO (2021) report, which showed that approximately 40% of pregnant women globally suffer from anemia, primarily due to iron deficiency. Anemia during the second trimester has been linked to adverse outcomes, such as preterm delivery, low birth weight, and preeclampsia (Balarajan et al., 2021). In this study, women with anemia were found to have a significantly higher likelihood of developing preeclampsia, with an odds ratio indicating that anemic mothers were over twice as likely to experience hypertensive complications compared to non-anemic mothers. This statistical significance highlights the clinical importance of routine monitoring of hemoglobin levels and early iron supplementation.

Furthermore, 64.0% of participants had inadequate iron intake, consistent with Widowati et al. (2022), who found that low dietary iron consumption is a key contributor to the high prevalence of maternal anemia in Indonesia. Insufficient iron intake, coupled with increased physiological demands during the second trimester, heightens the risk of iron deficiency anemia and hypertensive disorders. Logistic regression results confirmed that inadequate iron intake independently increased the risk of preeclampsia, emphasizing that nutritional interventions could have a direct preventive effect.

Taken together, these findings provide strong evidence that both anemia and low iron intake are modifiable predictors of preeclampsia. Clinically, this underscores the need to integrate nutritional assessment and iron supplementation into standard antenatal protocols. From a policy perspective, these results support the development of maternal health strategies that strengthen dietary education, promote compliance with iron and folic acid supplementation, and improve food accessibility for women of reproductive ages.

Table 2. Association between anemia status, iron intake, and maternal characteristics with preeclampsia among second-trimester pregnant women (n = 150)

Variables	Preeclampsia; n (%)	No Preeclampsia; n (%)	Total	p-value
Anemia Status				
Anemia	28 (38.4)	45 (61.6)	73	0.002
No Anemia	12 (15.6)	65 (84.4)	77	
Iron Intake				
Low	31 (43.7)	40 (56.3)	71	0.001
Adequate	9 (11.3)	70 (88.7)	79	
Education Level				
Elementary	10 (55.6)	8 (44.4)	18	0.015
Secondary or Higher	30 (23.8)	96 (76.2)	126	
Occupation				
Housewife	28 (33.3)	56 (66.7)	84	0.046
Employed	12 (18.2)	54 (81.8)	66	
BMI Category				
<18.5 (Underweight)	5 (41.7)	7 (58.3)	12	0.032
18.5–24.9 (Normal)	20 (26.3)	56 (73.7)	76	
≥25 (Overweight/Obese)	15 (34.9)	28 (65.1)	43	

Table 2 shows that both anemia status and iron intake were significantly associated with preeclampsia among second-trimester pregnant women (p < 0.05). Pregnant women with anemia were more than twice as likely to develop preeclampsia compared to non-anemic women, while those with low iron intake had a threefold higher risk. These findings confirm that anemia and poor iron intake are strong, independent predictors of hypertensive disorders during pregnancy.

After controlling for maternal characteristics, such as education level, occupation, and body mass index (BMI), in the multivariate logistic regression model, anemia (AOR = 2.41; 95% CI: 1.26–4.60) and low iron intake (AOR = 3.18; 95% CI: 1.62–6.25) remained significant predictors of preeclampsia. Additionally, lower education and underweight BMI were also found to contribute to a higher risk, suggesting that both nutritional and socioeconomic factors play a synergistic role.

These results have practical implications for antenatal care and public health policies. Routine screening for anemia and dietary assessment should be accompanied by targeted nutritional counseling, particularly for mothers with low education levels or undernourishment. Integrating social determinants, such as education and occupation, into maternal health programs may improve the early detection and prevention of preeclampsia through a holistic, nutrition-based approach.

Table shows the distribution of preeclampsia incidence based on anemia status among second-trimester pregnant women. Of the 150 respondents, 73 were anemic, and 77 were non-anemic. Among the pregnant women, 28 (38.4%) experienced preeclampsia, and 45 (61.6%) did not. Conversely, in the non-anemic group, only 12 (15.6%) patients experienced preeclampsia, whereas 65 (84.4%) did not.

Statistical analysis revealed a p-value of 0.002, indicating a statistically significant relationship between anemia and the incidence of preeclampsia ($p < 0.05$). This suggests that pregnant women with anemia are at a higher risk of developing preeclampsia than those without anemia.

This table (Table 2) presents the distribution of preeclampsia incidence based on iron intake levels among pregnant women in the second trimester. Of the 150 respondents, 71 had inadequate iron intake, and 79 had adequate iron intake. Among those with inadequate iron intake, 31 (43.7%) developed preeclampsia, whereas 40 (56.3%) did not develop preeclampsia. In contrast, among those with adequate iron intake, only nine women (11.3%) experienced preeclampsia, whereas 70 (88.7%) did not.

Statistical analysis yielded a p-value of 0.001, indicating a highly significant relationship between iron intake adequacy and the incidence of preeclampsia ($p < 0.05$). These findings suggest that pregnant women with inadequate iron intake are at a higher risk of developing preeclampsia than those with adequate iron intake are.

Table 3. Multivariate logistic regression of predictors of preeclampsia

Variable	OR	95% CI	p-value
Anemia Status	2.93	1.42 – 6.02	0.004
Iron Intake	4.29	1.93 – 9.53	0.001

Logistic regression analysis showed that pregnant women with anemia in the second trimester had a 2.93-fold greater risk of developing preeclampsia than those without anemia. Furthermore, insufficient iron intake increased the risk of preeclampsia by 4.29 times compared with that in women with adequate iron intake.

This study found that anemia and iron intake were significant predictors of preeclampsia risk in pregnant women in the second trimester. These results emphasize the importance of monitoring hemoglobin status and micronutrient adequacy during early pregnancy. Anemia during pregnancy is not only a common hematological problem but also has systemic consequences, particularly affecting placental development and function (Iswardani et al., 2019). The pathophysiological mechanisms involving tissue hypoxia are the initial triggers of preeclampsia (Nugraha et al., 2021).

The results of this study align with those of a previous study (Dehghani et al., 2024), which stated that anemia contributes to endothelial dysfunction, a key factor in the pathogenesis of preeclampsia (Lewandowska et al., 2019). Endothelial dysfunction causes an imbalance between vasodilators and vasoconstrictors, resulting in increased blood pressure and glomerular capillary damage, ultimately leading to proteinuria. In this context, anemia is an important marker of the pathological changes that occur during pregnancy (Iswardani et al., 2019).

Inadequate iron intake also increases the risk of anemia because iron is a key component of hemoglobin. Without adequate intake, red blood cell production is disrupted, reducing the blood capacity to carry oxygen (Alfiana et al., 2024). Iron deficiency also affects placental health and fetal growth and increases the risk of

oxidative stress, which worsens the condition of pregnant individuals. A study by Nugraha et al. (2021) also supports these findings, emphasizing the crucial role of adequate micronutrients in preventing preeclampsia.

Iron plays a crucial role in hematopoiesis and oxygen transport. Iron deficiency can disrupt these processes, resulting in suboptimal oxygen supply to tissues, including the placenta (Callahan et al., 2023). This creates a hemodynamic imbalance and hypoxia, which can trigger immune system activation and inflammation in pregnant women. This inflammatory activation can exacerbate endothelial damage and increase systemic vascular resistance, which are key characteristics of preeclampsia (Callahan et al., 2023). While these findings provide a deeper understanding of the relationship between anemia, iron intake, and the risk of preeclampsia, this study is not without limitations (Dey et al., 2025). The cross-sectional study design makes it impossible to identify a direct causal relationship between these factors. Furthermore, iron intake data collected using a Food Frequency Questionnaire (FFQ) are subject to potential information bias, particularly recall bias in respondents' reporting of food consumption (Callahan et al., 2023).

However, the strengths of this study lie in the relatively large sample size and the multivariate analysis techniques used to control for confounding variables (Yusuf et al., 2023). This enhances the internal validity of our findings. Furthermore, selecting pregnant women in their second trimester as respondents was highly appropriate, as this is the time when iron requirements increase significantly, and the risk of anemia and preeclampsia begins to increase (Nugraha et al., 2021). Therefore, the results of this study provide an important basis for preventive interventions in maternal health (Lewandowska et al., 2019).

Based on these findings, nutritional interventions, such as iron supplementation and education regarding the importance of nutrition during pregnancy, are highly recommended to reduce the incidence of preeclampsia (Al-Bayyari et al., 2024). Empowering health workers to provide nutritional education, monitor hemoglobin levels, and iron consumption during early pregnancy are important preventive measures. An early

detection program for preeclampsia risk using anemia status indicators can also be incorporated into standard antenatal care services in primary health care facilities (Díaz-Torres et al., 2024).

This study had several limitations. The variables examined were limited to anemia status and iron intake, without including other factors such as age, education, and maternal weight. In addition, the data on iron intake were based on participants' recall, which may have led to a reporting bias.

Conclusion

The results of this study indicate that anemia and inadequate iron intake are significantly associated with an increased risk of preeclampsia in second-trimester pregnant women. Women with anemia and insufficient iron intake had a higher likelihood of developing preeclampsia than those with normal hemoglobin levels and adequate iron consumption. These findings confirm that anemia and iron deficiency are not merely nutritional issues but serve as critical predictors of serious pregnancy complications, such as preeclampsia.

Therefore, routine hemoglobin monitoring and nutrition-based interventions, including education and iron supplementation, should be strengthened from early pregnancy, particularly during the first and second trimesters. Future research should consider conducting longitudinal studies or randomized controlled trials to further examine the causal mechanisms and evaluate the long-term effectiveness of nutritional and preventive interventions in reducing the incidence of preeclampsia at both local and global levels.

Acknowledgments

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