ONLINE FIRST

ORIGINAL ARTICLE

Analysis of Determinant Factors of Anemia Prediction Model for Prevention of Anemia in Pregnant Women

Pranajaya Pranajaya[1], Sudarmi Sudarmi[1]*, Dewi Purwaningsih[1], Emy Rianti[2]

[1]*Health Polytechnic Tanjungkarang, Midwifery Department, Lampung, Indonesia*
[2]*Health Polytechnic Jakarta 1, Nursing Department, Jakarta, Indonesia*
Correspondence: sudarmi@poltekkes-tjk.ac.id
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ABSTRACT

OBJECTIVE: To identify the main determinants of anemia and effective anemia prevention strategies among pregnant women.

METHODOLOGY: This was a quantitative study using a cross-sectional analytical survey design and a logistic prediction model. The population consisted of all pregnant women (159). A sample of 114 women was obtained using the "Slovin" formula. Data were collected through measurements, documentation, and questionnaires. The hypothesis was that there is a significant relationship between age, pregnancy spacing, parity, education, chronic energy deficiency (CED), and adherence to iron tablet consumption with the incidence of anemia. Data were analyzed using univariate percentage analysis, bivariate chi-square tests, and multivariate regression prediction models.

RESULTS: The determinants contributing to the incidence of anemia were adherence to iron tablet consumption (p-value = 0.001; OR = 26.59), chronic energy deficiency (CED) (p-value = 0.001; OR = 12.91), and pregnancy spacing (p-value = 0.002; OR = 4.95). Preventive measures for pregnant women include increasing adherence to iron supplementation, improving balanced nutrition, attending antenatal care (ANC), and planning pregnancies properly. For health workers, preventive efforts include increasing promotion and education, maintaining adequate pregnancy spacing, monitoring and supervising iron tablet consumption, treating comorbidities, and preventing anemia by involving mothers and empowering families.

CONCLUSION: Adherence to iron tablet consumption is the strongest determinant of anemia incidence. It is suggested that maternal involvement and family empowerment are needed in anemia prevention.

KEYWORDS: Determinants, Prediction Model, Prevention Anemia, Pregnant Women

INTRODUCTION

Anemia during pregnancy significantly compromises maternal and fetal health. It is associated with a higher incidence of adverse outcomes, such as intrauterine growth restriction, preterm birth, miscarriage, low birth weight, postpartum hemorrhage, and infection[1]. The World Health Organization (WHO) defines anemia in pregnancy as a hemoglobin concentration of less than 11 g/dl[2]. Pregnant women with iron-deficiency anemia face a higher risk of complications during pregnancy[3]

Globally, WHO estimates indicate that anemia affects 39.8% of children aged 6–59 months, 35.5% of pregnant women, and 30.7% of women aged 15–49 years[4]. In Indonesia, the prevalence of anemia among pregnant women remains high at 27.7% in 2023[5]. The prevalence of anemia in pregnant women in Lampung Province showed a slight increase, from 9.06% in 2019 to 9.10% in 2020[6]. In South Lampung Regency, it rose from 9.8% in 2020 to 10.2% in 2021, while in Tanjung Sari sub-district, it decreased slightly from 9.8% to 9.6%.[7]

The Ministry of Health has developed a long-term strategy for anemia management through four main activities: Communication, Information, and Education (CIE), supplementation, fortification, and cross-sectoral collaboration[8]. In 2022, the coverage of 90 iron tablets (Fe) for pregnant women in Lampung Province reached 91.95%; South Lampung Regency achieved 98.2%, and Tanjung Sari reached 96.7%. Programs also include home visits, nutritional consultations, supplementary feeding (PMT), and Hb level checks for prospective brides and grooms[9].

Anemia during pregnancy is influenced by maternal age, gestational age, parity, nutritional status, adherence to iron supplementation, pregnancy spacing, maternal knowledge, and family support[10]. The results of Ahmad's (2025) study showed that pregnant women at risk had a 0.140 times greater chance of experiencing anemia (p = 0.034), while mothers with high parity had a 3.628 times greater chance of experiencing anemia (p = 0.033)[11]. The results of the Frontiers (2025) meta-analysis linked anemia to the risk of preterm birth (RR = 1.51, 95% CI 1.33-1.72) and low birth weight (RR = 1.40, 95% CI 1.19-1.63)[12]. Although various programs have been implemented, anemia remains highly prevalent. Therefore, this study aims to examine the prevalence of anaemia among pregnant women, identify the main causative factors, and propose effective prevention strategies as an alternative approach.

Conceptual Framework

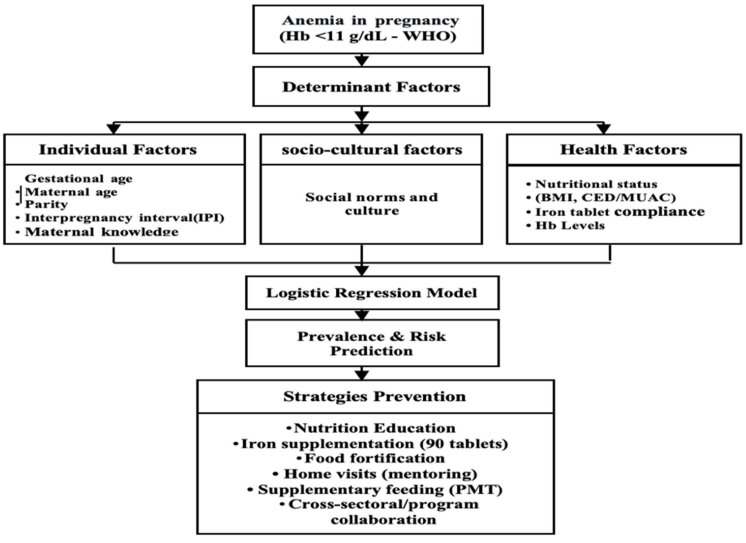

Figure 1: Conceptual Framework of the Analysis of Determinant Factors of the Anemia Prediction Model

METHODOLOGY

This study was quantitative, using a cross-sectional analytical survey design and logistic regression analysis.

Research Objective: To analyze the determinants of anemia as a preventive measure for pregnant women in Tanjung Sari District, South Lampung, Indonesia, from May to August 2024.

Research Hypothesis: "There is a significant relationship between maternal age, gestational age, interpregnancy spacing, parity, education level, cultural norms, Chronic Energy Deficiency (CED), and adherence to iron supplementation with the incidence of anemia in pregnant women."

Population: All pregnant women residing in the Tanjung Sari Community Empowerment Program (PKM) work area between May and June 2024 constituted the study population (N = 159).

Sample: The sample size was determined using the Slovin formula.

$$n = \frac{N}{1 + N\,(e)^2} \quad n = \frac{159}{1 + 159\,(0{,}05)^2} \quad n = \frac{159}{1{,}398} \quad n = 113{,}774 \quad \text{Rounding } n = 114$$

Description

n: sample size.

N: total population size.

e: maximum error rate or margin of error (0.05) with 95% accuracy

A sample of 114 pregnant women was selected using inclusion and exclusion criteria.

Inclusion criteria: healthy mothers, pregnant women residing in the study area, complete data, and willingness to provide informed consent.

Exclusion criteria: pregnant women with acute illness or pregnancy complications, a history of chronic illness before or during pregnancy, mental or communication disorders, or an inability to provide informed consent.

Data Collection: The dependent variable was anemia status, determined by measuring hemoglobin (anaemia: Hb < 11 g/dL according to WHO) with a HemoCue device. Data for the independent variables were collected through a structured questionnaire distributed to pregnant women, covering the following variables: maternal age, gestational age, interpregnancy interval, knowledge, cultural norms, nutritional status (MUAC), and adherence to iron tablets.

Operational definition

Anemia: The result of measuring hemoglobin levels in pregnant women, with a blood Hb concentration below 11 g/dL.

Chronic Energy Deficiency (CED): The result of measuring the mid-upper arm circumference (MUAC) of pregnant women. A mother is considered to have CED if her MUAC is less than 23 cm, while normal nutritional status is defined as MUAC greater than or equal to 23 cm.

Knowledge: The results of respondents' answers to 20 questions about anemia and its prevention. A mother is considered to have good knowledge if she achieves a score equal to or greater than the average score of the total knowledge assessment.

Cultural norms: The results of respondents' answers to 10 questionnaire items about cultural norms supporting anaemia prevention. Mothers are categorized as having supportive cultural norms if they obtain a score greater than or equal to the average score of the total cultural norm support questions.

Maternal age: The mother's current chronological age in years, categorized as at risk (<20 years and >35 years) and not at risk (20-35 years).

Gestational age: The age of the fetus in weeks since the first day of the last menstrual period (LMP), based on maternal and child health book records or ultrasound (USG), and categorized by trimester.
Pregnancy interval: The time interval in months between the birth of the previous child and the conception of the current pregnancy, categorized as <24 months (high risk) and ≥24 months (not at risk).
Compliance with Iron Tablet Consumption: Compliance was measured as the level of iron supplement tablet consumption relative to recommendations (90 tablets during pregnancy), categorized as compliant (≥90 tablets) or non-compliant (<90 tablets).
Data Analysis: Data were analyzed in stages. Univariate analysis used percentage distributions to describe respondent characteristics. Bivariate associations between independent variables and the incidence of anemia were assessed using the chi-square test at a significance level of $\alpha = 0.05$. Variables significant in the bivariate analysis were then entered into a multivariate logistic regression model to identify the determinants of anaemia. Data analysis was performed using SPSS.
Ethics approval: Ethical approval was granted by the Ethics Commission of Poltekkes Kemenkes Tanjungkarang No.506/KEPK-TJK/VII/2024.

RESULTS

Univariate Analysis

The distribution of anaemia frequency, the occurrence of anaemia and the factors causing anaemia in pregnant women are shown in **Table I**.

Table I: Frequency and Distribution of Prevalence of Anemia and Causal Factors

Variable	Frequency and Percentage	
	n	%
Dependent Variable		
Anemia Incident		
Anemia (Hb. < 11 gr %/dl)	34	29.82
Non Anemia (Hb > 11 gr%/dl	80	70.18
Independent Variable		
Gestational age		
High-risk (1st Trm & 3rd Trm)	55	48.25
Low-Risk (2nd Trm)	59	51.75
Maternal age		
High-risk (< 20 & >35 yr)	37	32.46
Low-risk (20-34 yr)	77	67.54
Parity		
> 2	39	34.21
< 2	75	65.79
Interpregnancy interval (IPI)		
< 2 years	38	33.33
> 2 years	76	66.67
Maternal knowledge		
Low	44	38.60
High	70	61.40
Social norms and culture		
Non-supportive	55	48.25
supportive	59	51.75
Chronic Energy Deficiency (CED)		
MUAC < 23,5 cm	19	16.67
MUAC > 23,5 cm	95	83.33
Compliance with iron tablet consumption		
Non-compliant	42	36.84
Compliant	72	63.16

Bivariate Analysis

The results of the bivariate analysis of anemia determinants and the incidence of anemia among pregnant women are shown in **Table II**.

Table II: Relationship Between Determinant Factors and the Incidence of Anemia in Pregnant Women

Determinants Anemia	Anemia				Total		OR (95% CI)	P-Value
	Yes		No					
	n	%	n	%	n	%		
Gestational age								
High-risk (1st Trm & 3rd Trm)	14	25.5	41	74.5	55	100	0.67 (0.30 – 1.51)	0.320
Low Risk (2nd Trm)	20	33.9	39	66.1	59	100		
Total	34	29.8	80	70.2	114	100		
Maternal age								
High-risk (< 20& >35 yr)	14	37.8	23	62.2	37	100	1.85 (0.88 – 3.90)	0.045
Low-risk (20-34 yr)	20	26.0	57	74	77	100		
Total	34	29.8	80	70.2	114	100		
Parity								
> 2	13	33.3	26	66.7	39	100	1.48 (0.69–3.16)	0.048
< 2	21	28.0	54	72.0	75	100		
Total	34	29.8	80	70.2	114	100		
Interpregnancy interval (IPI)								
< 2 years	21	55.3	17	44.7	38	100	5.99 (2.50 – 14.39)	0.001
> 2 years	13	17.	63	82.9	76	100		
Total	34	29.8	80	70.2	114	100		
Maternal knowledge								
Low	18	40.9	26	59.1	44	100	2.34 (1.03 – 5.32)	0.031
High	16	22.9	54	77.1	70	100		
Total	34	29.8	80	70.2	114	100		
Social norms and culture								
Non-supportive	16	29.1	39	70.9	55	100	0.94 (0.42 – 2.09)	0.860
supportive	18	30.5	41	69.5	59	100		
Total	34	29.8	80	70.2	114	100		
Chronic Energy Deficiency (CED),								
MUAC < 23,5 cm	15	78.9	4	21.1	19	100	15.00 (4.46 – 50.50)	0.001
MUAC > 23,5 cm	19	20.0	76	80.0	95	100		
Total	34	29.8	80	70.2	114	100		
Compliance with iron tablet consumption								
Non-compliant	29	69.0	13	40.0	42	100	29.89 (9.77 – 91.61)	0.001
Compliant	5	6. 9	67	93.1	72	100		
Total	34	29.8	80	70.2	114	100		

Multivariate Analysis

The final results of the multivariate analysis using logistic regression as a prediction model are presented in **Table III**. The variables included in the multivariate model were gestational age, maternal age, pregnancy spacing, parity, cultural norms, knowledge, chronic energy deficiency (CED), and adherence to iron tablet consumption.

Table III: Final Results of the Multivariate Logistic Regression Analysis Model Between Maternal Age, Parity, Pregnancy Spacing, Knowledge, CED and Compliance with Iron Tablet Consumption on the Incidence of Anemia

Variabel	β	p value	OR	95% CL
Compliance with iron tablet consumption	3.28	0.001	26.59	8.53 – 82.90
Chronic Energy Deficiency (CED)	2.56	0.001	12.91	3.72 – 44.80
Interpregnancy interval (IPI)	1.60	0.002	4.95	1.81 – 13.52
Maternal knowledge	0.75	0.031	2.12	1.07 – 4.22
Maternal age	0.29	0.086	1.34	0.83 – 2.16
Parity	0.33	0.079	1.39	0.64 – 3.02

DISCUSSION

Analysis of Compliance with Iron Supplementation and Its Association with Anemia Incidence and Prevention Strategies in Pregnant Women.

The multivariate logistic regression analysis showed a significant association between compliance with iron tablet consumption and the incidence of anemia (OR = 26.59; p = 0.001). Pregnant women who did not comply with iron tablet consumption had a 26.59 times higher likelihood of experiencing anemia than those who adhered to the recommendation. Compliance with iron tablet consumption is defined as the extent to which pregnant women follow the recommended iron tablet intake. Compliance with iron tablet supplementation among pregnant women is determined by both the accuracy of the number of tablets consumed and adherence to the recommended method of intake. The antenatal care program in Indonesia requires every pregnant woman to obtain and consume of at least 90 iron tablets during pregnancy, starting with the first visit to a health care facility[13].

During the second and third trimesters of pregnancy, maternal blood volume increases to support fetal development. Although iron requirements can generally be met through a healthy, balanced diet, dietary iron intake during pregnancy is often insufficient, making iron supplementation in the form of iron tablets necessary[14]. The WHO and national health agencies recommend oral iron supplementation at a daily dose of 30–60 mg of elemental iron[15]. The benefits of iron tablets are substantial in preventing anemia among pregnant women, but their effectiveness is often limited by low compliance with iron tablet use[16]. Failure to comply with iron supplementation during pregnancy can lead to reduced iron adequacy and a higher likelihood of pregnancy-related anaemia, particularly iron-deficiency anemia[17].

These findings are consistent with the results of a systematic review and meta-analysis by Fite on the prevalence and determinants of anemia among pregnant women in sub-Saharan Africa, which found that pregnant women who did not adhere to iron and folic acid supplementation were 1.82 times more likely to develop anaemia than those who complied[18]. Similarly, a study by Skolmowska on the prevention and treatment of iron-deficiency anaemia in pregnant women found that providing iron in larger amounts and giving double nutrients, accompanied by counselling, effectively prevented anemia in pregnant women[19].

Research findings regarding maternal non-compliance with iron tablet consumption indicate that the majority of mothers do not comply with the prescribed iron tablets due to uncomfortable side effects experienced during consumption, such as nausea, vomiting, heartburn, and constipation. As a result, mothers do not finish the prescribed iron tablets. Furthermore, mothers' lack of understanding of the benefits of iron tablets is also one of the reasons for non-compliance. Efforts to increase compliance among pregnant women in taking iron tablets can be improved through educational interventions and ongoing support[20]. Education should include the benefits of iron tablets for the mother and fetus, the role of iron in preventing anemia, the negative impacts of anemia, and the correct way to consume iron tablets, including the proper time of consumption, suitable food and drink combinations, and vitamin C intake to increase absorption[21]. Monitoring and supervision of iron tablet consumption by health workers or Posyandu cadres are also important. Health promotion, information, communication, and education should be strengthened to increase pregnant women's awareness of the importance of adhering to iron tablet regimens and their potential impact on both maternal and fetal health[22]. Involving the family, especially the husband, to remind and support maternal compliance with iron tablet use is expected to enhance pregnant women's independent awareness and encourage them to take iron tablets as recommended consistently.

Analysis of Chronic Energy Deficiency (CED) with Anemia Incidence and Its Prevention Strategies in Pregnant Women.

The multivariate analysis showed that chronic energy deficiency (CED) was significantly associated with anemia, with an odds ratio (OR) of 12.91 and a p-value of 0.001. This indicates that pregnant women with chronic energy deficiency (CED) are 12.91 times more likely to develop anemia than those without CED. Anthropometric measurements of mid-upper arm circumference (MUAC) below the threshold of 23.5 cm are an effective screening indicator for identifying women at risk of CED. A woman is considered to have CED if her MUAC is <23.5 cm22.

Pregnant women with CED can experience several risks and complications, including bleeding during pregnancy, anemia, low birth weight, and infectious diseases[23]. CED and anemia often coexist during pregnancy, primarily due to insufficient nutritional intake. In addition, dietary habits are a key contributing factor to the occurrence of CED[24].

The research findings showed that low protein and energy intake, which is insufficient to meet the daily needs of pregnant women, is the main cause of mothers experiencing CED. In addition, some pregnant women also perform heavy physical activities, such as working as factory workers. This excessive workload accelerates energy expenditure without being balanced by adequate nutritional compensation. The mother's level of knowledge about the importance of consuming balanced nutrition during pregnancy is one of the factors contributing to CED.

Supporting the present findings, Lipoeto reported that CED was the dominant nutritional risk factor for anemia among pregnant women in Indonesia, with an odds ratio of 3.81 (95% CI: 2.36–6.14)[25]. Supporting the current results, Geta TG 2022[26] reported in a systematic review and meta-analysis that pregnant women in Ethiopia with a MUAC below 23.5 cm were at significantly greater risk of anemia (RR = 2.35; 95% CI: 1.53–3.68). In line with these findings, Sandhi and ED found a statistically significant relationship between CED and the incidence of anemia in pregnant women ($p = 0.002$), with women experiencing CED having a 39-fold higher risk of anemia compared to those without CED[27].

Preventive measures for anaemia in pregnant women with CED include consuming foods rich in both micronutrients and macronutrients, and providing iron and folic acid supplements[28]. Balanced and varied nutritional intake should be increased, accompanied by vitamin C supplementation and maintenance of food consumption patterns during pregnancy[29]. Health workers should provide education and empower families about the importance of balanced nutrition during pregnancy, and implement appropriate nutritional management and treatment of comorbidities in pregnant women. A minimum of six antenatal care (ANC) visits during pregnancy is recommended, with a focus on monitoring weight gain, nutritional status (MUAC), and maternal hemoglobin levels[30]. Pregnant women who experience CED due to economic limitations can be supported through a Supplementary Food Provision Program in the form of ready-to-eat foods high in calories and protein to help meet energy and nutritional needs during pregnancy. Through this nutritional approach, education, and support from health programs, it is hoped that the risk of anemia among pregnant women with CED can be minimized and optimal maternal and fetal health can be ensured[31].

Analysis of Interpregnancy Interval (IPI) < 2 Years with Anemia Incidence and Prevention Efforts in Pregnant Women.

The multivariate logistic regression analysis showed that a pregnancy spacing interval of <2 years had an OR of 4.95 (p-value = 0.002). This means that pregnant women with an interpregnancy interval (IPI) of <2 years have a 4.95 times greater chance of experiencing anemia compared to pregnant women with a pregnancy spacing of >2 years. A healthy

pregnancy spacing is recommended to be more than 2 years and no more than 10 years[32]. Pregnancy spacing that is too short or too long affects both maternal health and the health of the fetus[33]. Pregnant women with a short previous pregnancy interval are likely to experience worse impacts on maternal and fetal health, especially in high-risk pregnancies[34].

A short pregnancy interval of <2 years is a risk factor that can cause maternal anemia in subsequent pregnancies because the form and function of the maternal reproductive organs may not have fully recovered. As a result, the function of the reproductive organs can be disrupted if another pregnancy and childbirth occur too soon. In addition, a short interval between pregnancies may lead to anemia because the mother's body has lost a considerable amount of blood during the previous delivery. The body does not have enough time to restore red blood cell levels because nutritional reserves, especially iron and other essential nutrients, may already have been depleted during the previous pregnancy and delivery[35].

This study is consistent with the findings of Onwuka CC et al.[36], on the effect of short interpregnancy intervals on maternal outcomes, which showed that the incidence of maternal anemia was significantly higher among women with short pregnancy intervals compared to controls (RR = 2.09; 95% CI: 1.44–3.03; $p < 0.001$).

Strategies to prevent anemia caused by pregnancy intervals of <2 years should include continuous health promotion by health workers on the importance of maintaining adequate pregnancy spacing through family planning programs that involve mothers and families in planning the next pregnancy. Other efforts that can be made include providing education to mothers about the dangers of short pregnancy spacing for maternal and fetal health and conducting regular hemoglobin level screening during pregnancy[37]. Maintaining an appropriate pregnancy interval gives the mother's body time to recover before becoming pregnant again, so anemia among pregnant women can be prevented.

CONCLUSION

The determinants of anaemia in pregnant women identified in this study were four factors associated with anaemia incidence of anemia in pregnant women: compliance with iron tablet use, Chronic Energy Deficiency (CED), pregnancy spacing, and pregnant women's knowledge about anaemia. Maternal compliance with iron tablet consumption was the most dominant factor associated with the incidence of anemia in pregnant women.
Efforts to prevent anemia by health workers should include increasing promotion and education about the importance of maintaining a healthy pregnancy spacing through family planning programs, the dangers of anemia for mothers and fetuses, the benefits of and supervision of iron tablet consumption, recommendations for balanced nutrition, treatment of comorbidities, and the implementation of supplementary feeding programs involving the family. Meanwhile, pregnant women should attend a minimum of 6 antenatal care (ANC) visits, monitor body weight and haemoglobin levels, take iron tablets regularly with family support, increase their intake of nutritious foods rich in vitamin C, maintain a healthy diet, and plan the next pregnancy by regulating pregnancy spacing.

LIMITATIONS

This study has several limitations that should be considered. It was conducted in a specific region of Indonesia, which may limit its generalizability to pregnant women in different socioeconomic, cultural, or geographic contexts, where the prevalence and determinants of anemia may differ due to variations in access to health services and nutritional intake. Potential confounding variables such as parasitic infections, genetic hemoglobinopathies (e.g., thalassemia), or detailed socioeconomic status, were not fully controlled and may have influenced the observed associations. Future research should address these gaps through prospective cohort designs, objective biomarkers, and multicenter approaches to strengthen the evidence base for anemia prevention strategies.

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Data Sharing Statement: The data supporting this study's findings are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

AUTHOR CONTRIBUTION

Pranajaya P: Data collection, analysis, interpretation, drafting, revision, and final approval.
Sudarmi S: Data collection, research data analysis, manuscript creation and editing.
Purwaningsih D: Data collection, research data analysis.
Rianti E: Research data analysis.

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