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Association Between Dietary Inflammatory Index Scores and Hemoglobin Levels Among Pregnant Women in Asahan Regency: A Cross-Sectional Study

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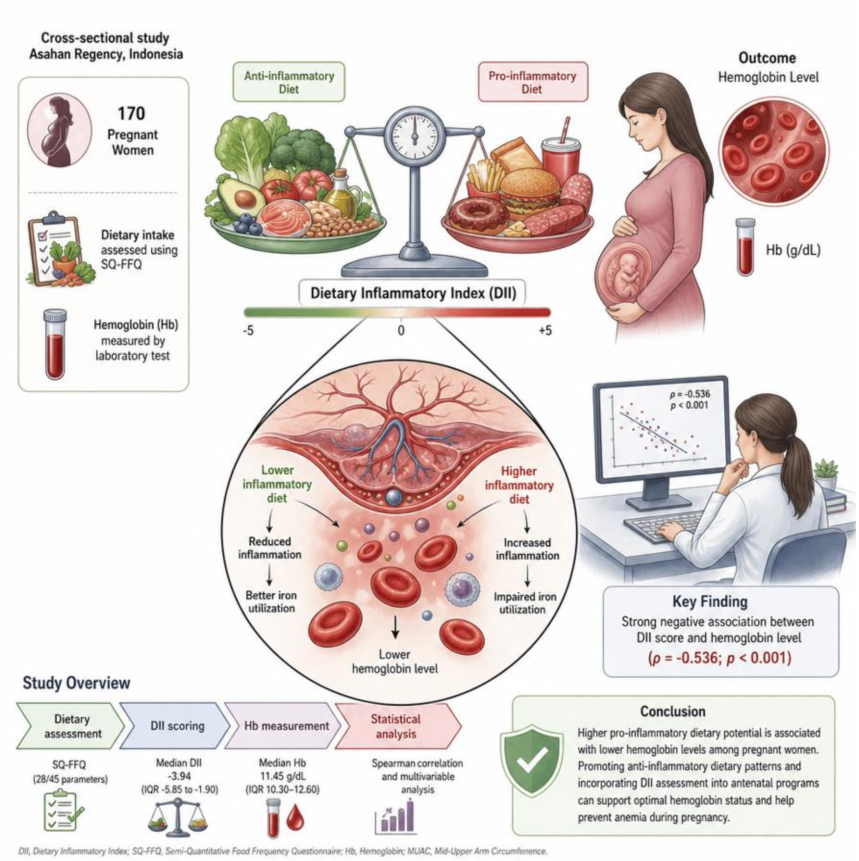
ABSTRACT

Anemia during pregnancy remains a major public health concern and is influenced not only by iron intake but also by dietary patterns that modulate inflammatory processes. The Dietary Inflammatory Index (DII) is a validated tool used to quantify the inflammatory potential of an individual's diet and may be associated with hemoglobin (Hb) levels. This study aimed to examine the association between DII scores and hemoglobin levels among pregnant women in Asahan Regency, Indonesia. A cross-sectional study was conducted among 170 pregnant women selected through purposive sampling. Dietary intake was assessed using a semi-quantitative food frequency questionnaire (SQ-FFQ), and DII scores were calculated using 28 out of 45 validated dietary parameters. Hemoglobin levels were obtained from laboratory measurements. Normality testing using the Kolmogorov–Smirnov test showed that both variables were not normally distributed; therefore, Spearman's correlation analysis was applied. The median hemoglobin level was 11.45 g/dL, while the median DII score was –3.94, indicating a predominantly anti-inflammatory dietary pattern. Spearman's correlation analysis revealed a strong and significant negative association between DII score and hemoglobin level ($\rho = -0.536$; $p < 0.001$), indicating that higher pro-inflammatory dietary potential was associated with lower hemoglobin concentrations. Multivariable analysis adjusting for maternal age, gestational age, parity, and mid-upper arm circumference (MUAC) confirmed that DII score remained an independent predictor of hemoglobin level. These findings highlight the importance of promoting anti-inflammatory dietary patterns during pregnancy to support optimal hemoglobin status and reduce the risk of anemia. Incorporating dietary inflammatory assessment into antenatal nutrition programs may strengthen anemia prevention strategies and improve maternal health outcomes.

Key Messages:

- Higher Dietary Inflammatory Index (DII) scores were significantly associated with lower hemoglobin levels among pregnant women.
- DII score remained the strongest independent predictor of hemoglobin levels even after adjusting for maternal age and MUAC.

GRAPHICAL ABSTRACT



INTRODUCTION

Pregnancy substantially increases iron requirements to support maternal hematologic adaptation and fetal growth. When these needs are not adequately met, hemoglobin (Hb) levels decline, and anemia may develop, contributing to increased maternal morbidity, postpartum hemorrhage, preterm birth, and low birth weight (1). Globally, anemia in pregnancy remains highly prevalent despite ongoing public health efforts. According to the most recent WHO Global Anaemia Estimates 2025, approximately 37% of pregnant women worldwide, representing more than 30 million women of reproductive age, are affected by anemia, indicating that the global burden has shown minimal improvement over recent years (2). In Indonesia, the 2018 National Basic Health Survey (RISKESDAS) reported that 48.9% of pregnant women were anemic, indicating a significant national public health challenge(3).

Growing evidence suggests that anemia is not solely determined by iron intake but is strongly influenced by inflammation. Chronic low-grade inflammation elevates cytokines—particularly interleukin-6 (IL-6)—which stimulate hepatic production of hepcidin, the hormone that inhibits intestinal iron absorption and traps iron in storage sites, leading to restricted erythropoiesis and functional iron deficiency. This inflammation-driven mechanism is well-established in anemia of inflammation(4).

Diet is an important, modifiable determinant of systemic inflammation and iron metabolism during pregnancy. The Dietary Inflammatory Index (DII) is a literature-derived tool that quantifies the inflammatory potential of an individual's overall diet by scoring multiple nutrients and foods on pro- and anti-inflammatory effects; higher DII scores indicate more pro-inflammatory diets. The DII was developed and validated to allow comparisons of inflammatory dietary patterns across populations and has been used widely in nutritional epidemiology(5). Higher DII scores indicate pro-inflammatory diets, which are associated with increased cytokines, elevated hepcidin, reduced iron absorption, and lower hemoglobin levels.

International studies have shown that higher DII scores are associated with a greater risk of anemia and reduced hemoglobin. A NHANES-based analysis found that individuals with higher DII scores

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had significantly lower hemoglobin, serum iron, and ferritin levels(6). A prospective cohort study among pregnant women reported that higher DII scores in early pregnancy predicted third-trimester anemia(7)

Despite increasing global evidence, studies examining DII and hemoglobin among pregnant women in Indonesia remain limited, especially in North Sumatra. In Asahan Regency , maternal anemia remains a public health concern. Dietary patterns in this area are largely characterized by traditional home-prepared foods rich in plant-based ingredients, resulting in an overall anti-inflammatory dietary profile, as indicated by predominantly negative DII scores. Nevertheless, relatively high intakes of total fat, saturated fat, and cholesterol persist due to the frequent use of coconut milk and animal-source foods in local cuisine, indicating a distinct and heterogeneous dietary inflammatory pattern. Therefore, this study aims to examine the association between DII scores and hemoglobin levels among pregnant women in Asahan Regency.

METHODS

This analytical cross-sectional study was conducted in the working areas of three community health centers in Asahan Regency, North Sumatra (Mutiara, Binjai Serbangan, and Silau Laut). Participants were selected using purposive sampling to ensure the inclusion of pregnant women who met specific eligibility criteria relevant to the study objectives and were accessible within routine antenatal care services. While this non-probability sampling approach facilitated efficient recruitment, it may limit the generalizability of the findings beyond the study setting. The required sample size was calculated using the formula proposed by Lwanga and Lemeshow, assuming a 95% confidence level (Z = 1.96), an expected prevalence of 30.3%, a 5% margin of error, and a total population of 252 women. An additional 10% was added to account for potential dropouts, resulting in a final sample size of 170 pregnant women. Eligible participants were pregnant women who were able to communicate clearly and provided written informed consent. Exclusion criteria included a diagnosis of tuberculosis, malaria, HIV, or hematologic disorders, as well as incomplete dietary or physical activity data. Dietary intake was assessed using a semi-quantitative food frequency questionnaire (SQ-FFQ) adapted from previously published studies and modified to reflect commonly consumed local foods. The questionnaire had been used in similar Indonesian populations, and internal consistency was evaluated during data collection to ensure acceptable reliability.

Dietary Intake Assessment and DII Calculation

Dietary intake was assessed using a validated Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) adapted from previous studies conducted in Indonesia (8) . The SQ-FFQ captured the frequency and portion size of foods consumed over the past month. Data collection was conducted through face-to-face interviews administered by trained nutritionists to ensure data accuracy and consistency.

All dietary data were entered into NutriSurvey software, using the Indonesian Food Composition Table (Tabel Komposisi Pangan Indonesia, TKPI) 2019 version, to estimate average daily energy and nutrient intake. These nutrient intake values were used to calculate the Dietary Inflammatory Index (DII).

The DII was calculated following the standardized methodology developed by Shivappa using the energy-adjusted DII (E-DII) approach to control for the potential confounding effect of total energy intake (5). Briefly, each food item from the SQ-FFQ was converted into grams per day, and nutrient intakes were standardized using global reference values by subtracting the global mean intake and dividing by the global standard deviation to obtain z-scores. These z-scores were converted to percentiles and then transformed into centered percentile scores by doubling the percentile value and subtracting one. The centered percentile scores were multiplied by their respective inflammatory effect scores derived from a comprehensive literature review linking dietary components to inflammatory biomarkers, including IL-6, CRP, IL-1β, IL-10, and TNF-α. The final DII score for each participant was calculated by summing all nutrient-specific inflammatory scores, with higher positive scores indicating more pro-inflammatory diets and negative scores reflecting anti-inflammatory dietary patterns.

A total of 28 out of the 45 commonly used DII parameters were included in this study: energy, protein, carbohydrates, total fat, saturated fat, trans fat, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), omega-3, omega-6, cholesterol, fiber, magnesium, iron, selenium, zinc,

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vitamin A, vitamin C, vitamin D, vitamin E, thiamine, riboflavin, vitamin B6, vitamin B12, folate, niacin, beta-carotene, caffeine, and tea. Several components, such as turmeric, garlic, and polyphenols, were excluded due to the absence of reliable data in the Indonesian food composition database(9). Nevertheless, the included parameters were considered sufficient to represent the inflammatory potential of the participants' diets.

Hemoglobin Measurement and Other Variables

Hemoglobin levels were measured from venous blood samples using a calibrated hematology analyzer. Anemia was defined according to World Health Organization (WHO) guidelines, with hemoglobin levels <11 g/dL in the first and third trimesters and <10.5 g/dL in the second trimester. This trimester-specific cutoff was applied consistently throughout the analysis.

Additional demographic and anthropometric data—including maternal age, gestational age, parity, and mid–upper arm circumference (MUAC)—were collected using structured questionnaires and direct measurements. MUAC was selected as the primary anthropometric indicator because it is less influenced by gestational weight gain and provides a more stable estimate of maternal nutritional status during pregnancy compared to body mass index (BMI).

Data Analysis

Data analysis was performed using SPSS version 25. The Kolmogorov–Smirnov test was used to assess the normality of the data. Because the DII score and hemoglobin levels were not normally distributed, the Spearman correlation test was applied to examine their association. Variables with $p < 0.25$ in the bivariate analysis were included in the multiple linear regression model. The final regression model was adjusted for maternal age, gestational age, parity, and mid-upper arm circumference (MUAC). All regression assumptions—including linearity, multicollinearity, and homoskedasticity—were met (VIF < 10). A p-value of < 0.05 was considered statistically significant. Ethical approval for this study was obtained from the Health Research Ethics Committee of the Faculty of Medicine, Diponegoro University (No. 079/EC/KEPK/FK-UNDIP/IV/2025). All participants provided written informed consent, and confidentiality, anonymity, and voluntary participation were ensured throughout the study.

CODE OF HEALTH ETHICS

Ethical approval for this study was granted by the Health Research Ethics Committee of the Faculty of Medicine, Diponegoro University, under approval number 079/EC/KEPK/FK-UNDIP/IV/2025.

RESULTS

A total of 170 pregnant women participated in this study. The median age was 28 years (range: 14–42 years). The median gestational age was 23 weeks (range: 1–38 weeks). The median MUAC was 26.45 cm, with values ranging between 18.3 and 36.2 cm. Respondents had a median parity of 2 (range: 1–5). The hemoglobin level had a median value of 11.45 g/dL (10.1–14.9), while the Dietary Inflammatory Index (DII) score had a median value of –3.94 (–5.39 to 2.12), indicating predominantly anti-inflammatory dietary patterns.

Table 1. Descriptive statistics of key variables (N = 170)

Variable	Median(min-max)
Age (years)	28.0(14–42)
Gestational age (weeks)	23.0 (1–37)
MUAC (cm)	26.45 (18.3–36.2)
Parity	2.0 (1–5)
Hemoglobin (g/dL)	11.45 (10.1–14.9)
DII score	–3.94 (–5.39 to 2.12)

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Correlation Between DII and Hemoglobin Levels

The Spearman correlation test demonstrated a strong negative and statistically significant relationship between DII score and hemoglobin levels ($\rho = -0.536$; $p < 0.001$). This indicates that a higher (more pro-inflammatory) DII score is associated with lower hemoglobin concentrations among pregnant women.

Table 2. Spearman Correlation Between DII Score and Hemoglobin Levels

Variable	Spearman rho	p-value
DII Score vs Hemoglobin	–0.536	<0.001*

*Significant at p < 0.01

A multiple linear regression model was conducted with hemoglobin level as the dependent variable. After adjusting for maternal age, MUAC, parity, and gestational age, the DII score remained the strongest independent predictor of hemoglobin levels. Higher DII scores significantly reduced hemoglobin levels ($\beta = -0.531$; $p < 0.001$). Maternal age showed a small positive significant association ($\beta = 0.177$; $p = 0.035$). Parity, MUAC, and gestational age were not significant predictors.

Table 3. Multiple Linear Regression Analysis of for Predictors of Hemoglobin Levels

Independent variable	Hemoglobin levels				
	B	Std. Error	Beta	*t*	*p value*
Parity	-0.069	-0.082	-0.070	-0.844	0.400
Maternal age	0.036	0.017	0.177	2.127	0.035
MUAC	0.023	0.021	0.073	1.110	0.268
Gestional Age	-0.015	0.008	-0.124	-1.931	0.055
DII SCORE	-0.280	0.034	-0.531	-8.241	0.001

*Significant at p < 0.05

DISCUSSION

The present study demonstrated a significant negative correlation between Dietary Inflammatory Index scores and hemoglobin levels among pregnant women in Asahan Regency. This finding indicates that higher dietary inflammatory potential is associated with reduced hemoglobin concentration, emphasizing the importance of maternal diet quality during pregnancy. Anemia remains a major global maternal health issue, and understanding dietary factors that contribute to its development is essential for improving maternal outcomes worldwide. Recent global data continue to show that diet plays a pivotal role in modulating inflammation and nutrient bioavailability during pregnancy.

The median hemoglobin concentration observed in this study (11.45 g/dL) suggests vulnerability to anemia, consistent with World Health Organization (WHO) guidelines defining anemia in pregnancy as hemoglobin levels <11 g/dL in the first and third trimesters (10). Increased iron requirements during pregnancy, combined with physiological hemodilution, increase susceptibility to hemoglobin decline, underscoring the importance of dietary quality and inflammatory balance in maintaining adequate iron status (11). Although the median DII score in this study (–3.94) reflects a predominantly anti-inflammatory dietary pattern, even modest increases toward a more pro-inflammatory DII were strongly associated with reductions in hemoglobin levels. This finding aligns with previous evidence suggesting that small shifts in dietary inflammatory potential can substantially influence systemic inflammation and iron regulation(12).

The negative median DII score observed may be partly explained by local dietary practices in Asahan Regency, where pregnant women commonly consume traditional home-prepared meals rich in plant-based ingredients and fish. Fish intake, which contributes anti-inflammatory fatty acids and micronutrients, may play a protective role in lowering overall dietary inflammatory potential. However, this generally anti-inflammatory pattern coexists with relatively high intakes of saturated fat and cholesterol, largely derived from coconut milk–based dishes and animal-source foods, resulting in a heterogeneous dietary inflammatory profile.

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Evidence from international studies supports the association found in this research. A prospective cohort study conducted in China reported that pregnant women with higher DII scores in the first and second trimesters had significantly elevated risks of developing anemia in the third trimester. The authors attributed this to the pro-inflammatory nature of certain dietary patterns that may impair iron absorption and metabolism(7). Similarly, an analysis of the U.S. National Health and Nutrition Examination Survey (NHANES) found that individuals with higher DII scores exhibited consistently lower levels of hemoglobin, serum iron, and ferritin(6). These studies align closely with the current findings, strengthening the external validity of the relationship between DII and hemoglobin levels.

Diets high in saturated fat, refined carbohydrates, and low in antioxidants can induce chronic systemic inflammation, leading to elevations in cytokines such as IL-6 and TNF-α. These cytokines stimulate hepatic production of hepcidin, a regulatory hormone that inhibits both intestinal iron absorption and iron release from stores. Elevated hepcidin levels subsequently decrease circulating iron availability and impair erythropoiesis, resulting in lower hemoglobin concentrations(13). This inflammation-driven disruption of iron homeostasis provides a plausible mechanistic explanation for the observed findings in this study.

A pro-inflammatory diet increases cytokines such as IL-6, which stimulates the liver to produce hepcidin. Hepcidin then binds to ferroportin—the only iron export channel—causing its degradation and blocking both intestinal iron absorption and the release of stored iron. This results in functional iron deficiency, where iron stores exist but cannot be used for red blood cell production.(14) In addition, pro-inflammatory diets are typically low in antioxidants, leading to oxidative stress and higher reactive oxygen species (ROS). These processes further activate inflammatory pathways, increasing IL-6 and hepcidin levels. Altogether, ferroportin suppression, restricted iron availability, and oxidative stress provide a clear explanation for why higher DII scores are associated with lower hemoglobin levels in pregnant women.(15)

Emerging literature also supports the role of specific dietary patterns in determining iron status. A recent study from the European Journal of Nutrition identified a ferritin-related dietary pattern among pregnant women, characterized by higher intakes of fish, soy products, nuts, and certain traditional foods. This pattern was positively associated with hemoglobin, serum iron, and ferritin levels, demonstrating that dietary patterns rich in nutrient-dense foods may support optimal iron status (16). Additionally, results from the EPIC-EurGast cohort showed that dietary and lifestyle factors, including heme iron intake and alcohol consumption, were associated with serum ferritin and iron excess, emphasizing the complex interaction between diet, inflammation, and iron homeostasis.

Other dietary components also play an important role. Iron absorption is influenced by enhancers such as vitamin C and inhibitors such as calcium, phytate, and polyphenols. A meta-analysis reported that high calcium intake significantly reduced iron absorption(17). while phytate-rich diets were shown to decrease non-heme iron bioavailability, particularly in cereal-based populations. These findings highlight that both inflammatory load and nutrient interactions shape iron status during pregnancy.(18)

A strength of the present study is the use of the DII to quantify dietary inflammatory potential, providing a comprehensive measure of dietary quality beyond single nutrient analysis. However, its cross-sectional design limits causal interpretation. Dietary data relied on FFQs, which may introduce recall bias. The absence of biomarkers such as C-reactive protein (CRP) or hepcidin also limits mechanistic interpretation. Despite these limitations, the significant association observed contributes meaningful evidence to the limited literature from Southeast Asia.

These findings underscore the importance of integrating dietary counseling emphasizing anti-inflammatory food choices into routine antenatal care. Encouraging pregnant women to consume nutrient-dense foods such as fruits, vegetables, whole grains, legumes, fish, and vitamin C–rich foods, while reducing processed and high-fat foods, may help support optimal hemoglobin levels and reduce the risk of anemia. Future research should explore longitudinal effects of dietary inflammatory potential on iron biomarkers and investigate culturally relevant dietary interventions aimed at improving maternal nutritional and hematological outcomes.

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CONCLUSION

This study found a significant inverse association between the Dietary Inflammatory Index (DII) and hemoglobin levels among pregnant women in Asahan Regency, with DII identified as the strongest predictor. Maternal age was also positively associated with hemoglobin levels, indicating that dietary and demographic factors should be jointly considered in maternal nutrition interventions. Pro-inflammatory diets may reduce hemoglobin levels by promoting inflammation-mediated iron sequestration, suggesting that anemia prevention strategies should address not only iron intake but also the overall inflammatory quality of the diet. In routine antenatal care, DII-based dietary assessment could be used by health workers to identify pregnant women at higher risk of inflammation-related anemia and to guide targeted, food-based nutrition counseling focused on anti-inflammatory dietary patterns. Future studies should apply longitudinal designs and include inflammatory biomarkers, such as C-reactive protein and hepcidin, to clarify causal pathways. Incorporating locally consumed anti-inflammatory foods into dietary assessment tools is also recommended to enhance contextual relevance.

DECLARATION OF THE USE OF AI

The authors declare that no artificial intelligence (AI), AI-assisted technologies, or large language models (LLMs) were used in the conception of the study, data analysis, or the drafting, writing, and editing of this manuscript

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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