

Vitamin C Intake Adequacy and the Incidence of Anemia in Pregnant Women: A Cross-Sectional Study at Totoli Community Health Center, Majene Regency

Kecukupan Asupan Vitamin C dan Kejadian Anemia pada Ibu Hamil: Studi Potong-lintang di Puskesmas Totoli, Kabupaten Majene

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Abstract: Anemia during pregnancy constitutes a major public health concern in Indonesia, with inadequate micronutrient intake, particularly vitamin C, identified as a key contributing factor. Vitamin C (ascorbic acid) facilitates the absorption of non-heme iron, thereby playing a critical role in hemoglobin synthesis. This study aimed to examine the relationship between vitamin C intake adequacy and the incidence of anemia among pregnant women in the working area of Totoli Community Health Center, Majene Regency, West Sulawesi. A cross-sectional observational design was employed, involving 106 pregnant women in the first and second trimesters selected via simple random sampling. Dietary assessment was conducted using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), hemoglobin levels were measured using the Easy Touch GCHb digital device, and anemia was defined based on the Indonesian Ministry of Health criteria (Hb <11 g/dL for trimesters I and III; <10.5 g/dL for trimester II). Results indicated that 34.9% of subjects were anemic, and 46.2% had inadequate vitamin C intake (mean: 57.18 mg/day; 2019 Recommended Dietary Allowances: ≥95 mg/day during pregnancy). Among subjects with inadequate vitamin C, 51.0% were anemic, compared to 21.1% among those with adequate vitamin C. Bivariate analysis using the Chi-square test revealed a statistically significant association between vitamin C adequacy and the incidence of anemia ($p = 0.001$). These findings underscore the importance of improving vitamin C consumption through fruit, vegetable, and dietary diversification programs to support iron absorption and reduce anemia risk during pregnancy.

Key word: anemia, hemoglobin, vitamin C, iron absorption

1. INTRODUCTION

Anemia in pregnancy is a hematological condition defined by the World Health Organization (WHO) as a hemoglobin (Hb) concentration below 11.0 g/dL in the first and third trimesters, and below 10.5 g/dL in the second trimester. It is among the most prevalent nutritional disorders worldwide, affecting an estimated 36.5% of pregnant women globally in 2019 (1). A landmark pooled analysis of population-representative data from 197 countries and territories documented that the global prevalence of any-severity anemia in pregnant women remained persistently high between 2000 and 2019, with insufficient progress toward international nutrition targets(2). In low- and middle-income countries (LMICs), anemia during pregnancy contributes substantially to maternal and perinatal morbidity and mortality, increasing risks of postpartum hemorrhage, infection, preterm birth, intrauterine growth restriction, and low birth weight (3). Indonesia recorded a national anemia prevalence of 48.9% among pregnant women in the 2018 National Basic Health Research, rising from 37.1% in 2013, with the

highest burden (84.6%) in women aged 15–24 years(4). The 2023 Indonesia Health Survey reported a decline to 27.7%; however, this figure still exceeds the WHO threshold of >20% for a moderate public health problem (5). In West Sulawesi Province, 2018 National Basic Health Research recorded a provincial anemia prevalence of 13.68%, while Majene Regency documented an increase in pregnancy-related anemia cases from 875 cases (2020) to 954 cases (2021), signaling an upward local trend (4).

Iron-deficiency anemia accounts for the largest proportion of anemia during pregnancy, particularly in developing countries. Population-level evidence consistently demonstrates that mean hemoglobin (Hb) concentrations among pregnant women vary substantially by region and income level. A comprehensive pooled analysis by Stevens et al. (2022), which modeled hemoglobin distributions from 4.5 million individual measurements across 489 data sources in 133 countries, reported that the global prevalence of any-severity anemia in pregnant women was 36.5% in 2019, indicating that more than one-third of pregnant women worldwide had hemoglobin levels below the WHO diagnostic threshold of 11.0 g/dL(6) The burden was markedly higher in low- and middle-income countries (LMICs), where the estimated anemia prevalence among pregnant women reached as high as 40–52% in sub-Saharan Africa and South and Southeast Asia (6). These findings are corroborated by the WHO Global Anaemia Estimates (2025), which report that 36.5% of pregnant women globally remained anemic in 2019, with insufficient progress toward the World Health Assembly target of halving anaemia prevalence by 2030 (1). The clinical significance of hemoglobin below 11.0 g/dL is well-established: a global systematic review and meta-analysis by Young et al. (2023) which comprising 272 studies confirmed that low maternal Hb (<11.0 g/dL) at any trimester is associated with significantly increased odds of low birthweight, preterm birth, stillbirth, and postpartum hemorrhage (7). Iron bioavailability from food, especially from non-heme iron, which dominates plant-based diets, is critically dependent on co-ingested dietary enhancers and inhibitors. Ascorbic acid (vitamin C) is the most potent nutritional enhancer of non-heme iron absorption: it chemically reduces ferric iron (Fe^{3+}) to the more soluble and absorbable ferrous form (Fe^{2+}), and forms soluble iron–ascorbate chelates that resist precipitation by dietary inhibitors such as phytates and polyphenols (tannins) (8). Conversely, phytates from legumes and cereals, and polyphenols from tea and coffee, form insoluble iron complexes and substantially reduce non-heme iron bioavailability (9). Given that the study population relies heavily on plant-based staples with co-consumption of iron-inhibiting beverages, adequate vitamin C intake becomes especially critical in this setting.

The Recommended Dietary Allowances recommends a vitamin C intake of ≥ 95 mg/day for pregnant women (10). Despite this recommendation, vitamin C deficiency remains highly prevalent among pregnant women in Indonesia. A systematic review and meta-analysis by Agustina et al. (2023), which analyzed 53 studies on nutrient intakes of pregnant and lactating women in Indonesia and Malaysia, reported that water-soluble vitamin intakes, including vitamin C, among Indonesian pregnant women consistently fell below 80% of the Estimated Average Requirement (EAR), classifying the majority of pregnant women as having inadequate vitamin C intake (11). At the individual study level, a cross-sectional study among 203 pregnant women in Bogor District, Indonesia, found that more than 80% of pregnant women had deficient vitamin C intake, driven primarily by low fruit and vegetable consumption, with fewer than 45% of pregnant women reporting any fruit consumption on the day of dietary recall (12). These figures highlight a systemic dietary gap in vitamin C intake across diverse Indonesian settings. Epidemiological data from Indonesian pregnant women consistently identify iron and micronutrient intake deficiencies including vitamin C as key modifiable risk factors for

anemia(13). Limited local evidence specifically examines the relationship between dietary vitamin C adequacy and anemia at the primary healthcare level in West Sulawesi. This study therefore aimed to determine whether vitamin C intake adequacy is significantly associated with the incidence of anemia among pregnant women in the working area of Totoli Community Health Center, Majene Regency, West Sulawesi.

2. METHODS

This study employed an analytical observational design with a cross-sectional approach. Data were collected from April to May 2025 at the Puskesmas Totoli Primary Healthcare Center, located in Majene Regency, West Sulawesi Province, Indonesia. The study population consisted of all pregnant women in their first and second trimesters registered at Puskesmas Totoli during the study period. Using simple random sampling, a final sample of 106 pregnant women was recruited. Inclusion criteria were: (1) pregnant women at gestational age of trimester I (0–12 weeks) or trimester II (13–27 weeks); (2) residing in the working area of Puskesmas Totoli; and (3) willing to provide informed consent. Exclusion criteria included pregnant women in their third trimester, those with severe systemic illness, and those who refused hemoglobin examination. Dietary assessment was conducted through structured face-to-face interviews using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), which captured the type, frequency, and quantity of food consumed over the past month. Food portions were estimated using standard household measurement guides. Vitamin C intake was calculated using the Indonesian Nutrient Composition Table and compared against the 2019 Recommended Dietary Allowances for pregnant women. Vitamin C intake was categorized as: (1) Inadequate: <95 mg/day; (2) Adequate: ≥95 mg/day. Hemoglobin measurement was performed using the Easy Touch GCHb digital device, a validated point-of-care hemoglobin analyzer, on capillary blood obtained from finger prick. Anemia was defined as Hb <11 g/dL for trimesters I and III, and Hb <10.5 g/dL for trimester II, in accordance with the Indonesian Ministry of Health guidelines (14). Univariate analysis was conducted to describe the distribution of study variables, including vitamin C intake adequacy and anemia status. Bivariate analysis using the Chi-square test (χ^2) was performed to assess the statistical association between vitamin C adequacy and anemia incidence. Statistical significance was set at $p < 0.05$. All analyses were performed using SPSS version 25.0. This study was approved by ethic committee Fakultas Ilmu Kesehatan Universitas Sulawesi Barat. Written informed consent was obtained from all participants prior to data collection. Confidentiality of data was maintained throughout the study.

3. RESULTS

A total of 106 pregnant women participated in this study. Most participants (80.2%) were in the reproductive age range of 20–35 years. Regarding gestational age, 21.7% were in the first trimester and 78.3% were in the second trimester. Third-trimester women were intentionally excluded from the study, given that they typically receive routine iron supplementation and nutritional monitoring, which could confound the relationship between dietary intake and anemia status. Most respondents were homemakers (95.3%), and the majority held secondary education qualifications (SMA/SMK/MA: 49.1%). All participants received iron supplementation tablets (Tablet Tambah Darah/TTD) as part of routine antenatal care.

Table 1. Distribution of Vitamin C Intake Adequacy Among Pregnant Women at Puskesmas Totoli, Majene (n = 106)

Vitamin C Adequacy	n	%
Inadequate (<95 mg/day)	49	46.2
Adequate (≥95 mg/day)	57	53.8
Total	106	100.0

Source: Primary Data, April–May 2025

The mean daily vitamin C intake among respondents was 57.18 mg/day, which falls substantially below the AKG 2019 recommendation of ≥95 mg/day for pregnant women. As shown in Table 1, 46.2% of respondents had inadequate vitamin C intake. The predominant sources of vitamin C in the respondents' diets were papaya, banana, and watermelon; however, the frequency and portion size of consumption were insufficient. High-vitamin C foods such as citrus fruits, dragon fruit, apple, grape, and Moringa leaves were seldom consumed or entirely absent from many respondents' diets.

Table 2. Distribution of Anemia Status Among Pregnant Women at Puskesmas Totoli, Majene (n = 106)

Anemia Status	n	%
Non-Anemic (Hb ≥11.0 g/dL Trimester I; ≥10.5 g/dL Trimester II)	69	65.1
Anemic (Hb <11.0 g/dL Trimester I; <10.5 g/dL Trimester II)	37	34.9
Total	106	100.0

Source: Primary Data, April–May 2025

The overall anemia prevalence among study participants was 34.9% (Table 2), indicating that approximately one in three pregnant women at Puskesmas Totoli was anemic. This figure exceeds the 2023 national anemia prevalence of 27.7% and reflects a significant local burden, consistent with prior reports from the same region.

Table 3. Cross-Tabulation of Vitamin C Intake Adequacy and Anemia Incidence Among Pregnant Women at Puskesmas Totoli, Majene (n = 106)

Vitamin C Adequacy	Anemia Status				Total		p-value
	Non-Anemic	%	Anemic	%	n	%	
Inadequate	24	48.98	25	51.02	49	46.2	0.001
Adequate	45	78.95	12	21.05	57	53.8	
Total	69	65.1	37	34.9	106	100.0	

Source: Primary Data, April–May 2025 | Chi-square test

As presented in Table 3, among pregnant women with inadequate vitamin C intake (n = 49), 51.0% were classified as anemic and 49.0% were non-anemic. In contrast, among those with adequate vitamin C intake (n = 57), only 21.1% were anemic and 78.9% were non-anemic. Chi-square statistical analysis confirmed a significant association between vitamin C intake adequacy and anemia incidence (p = 0.001, p < 0.05). These findings indicate that pregnant women with inadequate vitamin C intake are significantly more likely to experience anemia compared to those with adequate intake.

4. DISCUSSION

This study demonstrated a statistically significant association between vitamin C intake adequacy and the incidence of anemia in pregnant women at Puskesmas Totoli, Majene ($p = 0.001$). This finding is biologically coherent and consistent with the established mechanistic role of ascorbic acid in iron metabolism. Vitamin C enhances the bioavailability of non-heme iron, the predominant iron form in plant-based diets, by reducing ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}), which is the only form absorbable by intestinal mucosa through the divalent metal transporter 1 (DMT1). Additionally, vitamin C chelates iron to form soluble iron-ascorbate complexes that resist precipitation by inhibitory dietary compounds such as phytates and polyphenols (tannins). Without adequate vitamin C co-ingested with iron-containing foods, non-heme iron bioavailability from plant-based sources is substantially limited; absorption rates vary by food type and have been documented at approximately 2% from dried legumes, 4% from grains, and 7–9% from green leafy vegetables under low-enhancer conditions. The co-presence of ascorbic acid enhances fractional non-heme iron absorption in a dose-dependent manner—with one controlled study demonstrating an increase in absorption from 0.8% to 7.1% as ascorbic acid doses were incrementally raised—though the magnitude of this enhancement varies considerably with the amounts of co-ingested inhibitors (phytates, polyphenols) present in the meal (8). In general, the absorption of non-heme iron across dietary contexts has been reported to range from 1% to 10%, with vitamin C consistently identified as the most effective dietary enhancer (9).

The finding that 51.0% of women with inadequate vitamin C were anemic, more than double the proportion (21.1%) among those with adequate intake, underscores the practical significance of this micronutrient during pregnancy. The mean daily vitamin C intake of 57.18 mg/day was markedly below the RDA 2019 recommendation of ≥ 95 mg/day (10), reflecting a population-wide dietary deficit. Several interrelated factors may explain this deficit in the Majene context. Socioeconomic constraints likely limit household purchasing capacity for fresh fruits and vegetables, which constitute the principal dietary sources of vitamin C. Food accessibility barriers in semi-urban areas, including limited variety and availability of fresh produce in local markets, further restricting dietary diversity. Cultural dietary patterns in West Sulawesi tend to prioritize carbohydrate-based staples (rice, cassava) over fruit and vegetable consumption, and fresh fruit is often consumed irregularly rather than as a daily dietary component. Seasonal variability in the supply of tropical fruits may create periodic shortfalls in vitamin C availability throughout the year. Furthermore, common cooking practices such as prolonged boiling substantially degrade the thermolabile vitamin C content of vegetables, reducing effective dietary intake even when vitamin C-containing foods are consumed. Evidence from a comparable LMIC context, a cross-sectional study among pregnant women in Southern Ethiopia, similarly found that low dietary diversity, driven by socioeconomic constraints and limited food access, was independently associated with higher anemia prevalence, suggesting that the structural barriers to adequate micronutrient intake observed in Majene reflect a broader pattern in low-resource settings (15). Accordingly, locally available vitamin C-rich foods such as citrus, dragon fruit, guava, and *Moringa oleifera* (kelor) leaves were infrequently consumed or rarely incorporated into respondents' regular diets. *Moringa oleifera* (locally known as *kelor*), a plant widely cultivated across West Sulawesi and culturally familiar in local communities, warrants emphasis as a promising locally available, low-cost food-based strategy for addressing maternal micronutrient deficiencies in this setting. Its leaves are rich in iron, vitamin C, folate, and other

hematopoietic micronutrients essential for anemia prevention during pregnancy. A narrative review of 12 controlled studies involving pregnant and breastfeeding women, demonstrated that *Moringa oleifera* supplementation was associated with measurable improvements in maternal hemoglobin levels and micronutrient status, underscoring its potential as a practical, scalable, and contextually appropriate dietary intervention for populations with high anemia burden and constrained food environments (16).

These results are consistent with several studies. Cahyani found a significant correlation between vitamin C intake adequacy and anemia in pregnant women at a primary health center in Buleleng, Bali (17), and a systematic literature review by Salsabil and Nadhiroh confirmed the epidemiological relevance of vitamin C in modulating iron absorption and anemia risk across multiple Indonesian population groups (18). Samuel, in a cross-sectional study of 550 pregnant women attending antenatal care services in Southern Ethiopia, found that low dietary diversity including inadequate fruit and vegetable consumption was a significant independent determinant of anemia among pregnant women (15). Furthermore, a systematic review and meta-analysis by Seid, reported that inadequate dietary diversity during pregnancy approximately doubled the odds of maternal anemia, and that monotonous plant-based diets low in vitamin C-rich foods constituted a shared risk factor across LMIC settings (19).

Notably, 21.1% of women with adequate vitamin C intake still experienced anemia. This indicates that vitamin C deficiency is not the sole determinant of anemia, and that other factors contribute to its etiology. Given that the study population relied heavily on plant-based protein sources (tempe: 99.1%; tahu: 98.1%) and consumed iron-inhibiting beverages (tea, coffee), the compound inhibitory burden from phytates and polyphenols may have partially offset the protective effect of vitamin C (9). Iron intake was also identified as a significant additional determinant in this population. Multiple epidemiological studies in Indonesia have consistently identified concurrent deficiencies in dietary iron, folic acid, and protein as key modifiable risk factors for anemia in pregnant women (13). All participants were documented to have received iron-folic acid supplementation as part of routine antenatal care. While it is plausible that iron supplementation may have partially contributed to hemoglobin maintenance in some women with inadequate vitamin C intake (49.0% remained non-anemic), any attribution of this outcome to iron supplementation must be interpreted with considerable caution (20). The present study did not assess supplementation compliance, regularity of tablet intake, duration of use prior to hemoglobin measurement, or prescribed dosage, all of which substantially influence hemoglobin outcomes. This limitation is particularly relevant in the Indonesian context: national program data indicate that only approximately 20% of pregnant women adhered adequately to iron supplementation, and systematic analyses of the IFA supplementation program across multiple Indonesian provinces reported coverage rates well below 50%. However, the fact that supplementation did not fully prevent anemia in the inadequate vitamin C group (51.0% anemic) suggests that dietary vitamin C still plays a critical role in potentiating iron absorption even when supplemental iron is provided. This aligns with evidence that ascorbic acid co-administration significantly enhances the absorption of supplemental non-heme iron (8). From a public health perspective, these findings highlight the need for targeted dietary interventions to improve vitamin C intake among pregnant women in the Majene area. Antenatal care counseling should emphasize the food-based synergistic strategy of consuming iron-rich and vitamin C-rich foods simultaneously, for example, pairing tempe or fish with fresh fruits or locally available vitamin C-rich leafy

vegetables such as Moringa (kelor) and spinach. Community-based promotion of locally available vitamin C-rich foods should be incorporated into routine antenatal care programs (21). Healthcare providers should further advise pregnant women to limit tea and coffee consumption during or immediately after meals, given their documented inhibitory effects on iron absorption(9).

This study has several limitations. First, the cross-sectional design inherently precludes causal inference. The temporal sequence between inadequate vitamin C intake and the development of anemia cannot be established; it remains possible that confounders unmeasured in this study were responsible for both lower vitamin C intake and higher anemia risk simultaneously. Second, dietary vitamin C intake was assessed solely through the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), a self-reported recall-based instrument that is subject to well-documented measurement limitations. Respondents may over or underestimate the frequency and portion sizes of consumed foods due to memory limitations, social desirability bias, or difficulty in accurately recalling infrequently consumed items. Importantly, even when food consumption is recalled correctly, differences in storage conditions and cooking practices, particularly prolonged heat exposure, can substantially reduce the actual vitamin C content of foods relative to composition table values, leading to systematic overestimation of true effective intake. Additionally, plasma or serum vitamin C concentrations were not measured in this study. Dietary recall data alone does not directly reflect biochemical vitamin C status, as plasma vitamin C is influenced not only by intake but also by individual absorption efficiency, metabolic demand, stress, and inflammation status. Also, serum ferritin concentrations were not obtained. Hemoglobin measurement alone is insufficient to confirm iron-deficiency anemia (IDA) as the specific etiology, because low hemoglobin can result from multiple causes including vitamin B12 deficiency, folate deficiency, hemolytic anemia, and anemia of chronic disease. Future research should employ a longitudinal or prospective design and control for confounding variables including inflammation status, iron supplementation compliance, and dietary diversity.

5. CONCLUSION

This study demonstrated a significant association between vitamin C intake adequacy and the incidence of anemia among pregnant women in the working area of Puskesmas Totoli, Majene Regency, West Sulawesi ($p = 0.001$). Women with inadequate vitamin C intake had a substantially higher anemia rate (51.0%) compared to those with adequate intake (21.1%), highlighting the role of ascorbic acid as an enhancer of non-heme iron absorption. The mean daily vitamin C intake of 57.18 mg/day was below the recommended 95 mg/day, indicating a population-wide dietary deficit. To address this, antenatal care programs should incorporate nutrition education focused on increasing vitamin C-rich food consumption and optimizing dietary strategies to enhance iron bioavailability. Future research using longitudinal designs is warranted to establish temporal causality and to control confounding variables such as iron supplementation compliance, inflammatory status, and dietary inhibitor intake.

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