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(Research/ Review) Article

The Effectiveness of Iron Supplementation Combined with Vitamin C on Increasing Hemoglobin Levels Among Pregnant Women

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Abstract: Gestational anemia remains a critical public health issue that significantly increases the risk of maternal and fetal complications. Despite high distribution rates of iron tablets in Deli Serdang, the incidence of anemia among pregnant women continues to rise due to low compliance and poor intestinal absorption. This quantitative study applied a pre-experimental One-Group Pretest-Posttest design in Wonosari Village, Tanjung Morawa, to evaluate the clinical effectiveness of co-administering oral iron tablets combined with Vitamin C on increasing maternal hemoglobin levels. A sample of 39 pregnant women was selected using purposive sampling. Capillary hemoglobin levels were measured using digital point-of-care testing before and after the intervention, with data analyzed via the Paired Sample t-Test. Laboratory findings showed that the mean hemoglobin level rose significantly from 11.21 g/dL at pretest to 13.60 g/dL at posttest, demonstrating a mean absolute increase of 2.39 g/dL. The proportion of healthy respondents rose from 66.65% to 97.43%, while mild anemia cases dropped from 33.35% to 2.57%. The inferential statistical analysis generated a value of $p < 0.000$, proving that the co-administration of oral iron tablets alongside Vitamin C is highly effective in elevating maternal hemoglobin levels and eradicating gestational anemia.

Keywords: Anemia; Hemoglobin; Iron Tablets; Pregnancy; Vitamin C.

1. Introduction

Pregnancy is a natural physiological process that triggers profound maternal adaptations to support fetal growth and development within the uterus, yet it introduces severe hematological changes that primarily alter the maternal body's circulatory dynamics. During gestation, the maternal blood volume experiences a progressive expansion that begins as early as the first trimester and reaches its physiological peak at approximately 32 to 34 weeks of pregnancy. This dramatic alteration elevates plasma volume by 40% to 45%, whereas the absolute mass of erythrocytes increases by only 20% to 30% due to erythropoietin stimulation. This disproportionate expansion creates a significant imbalance between plasma and red blood cells, inducing physiological hemodilution which naturally drops the maternal hemoglobin concentration. If this systemic drop in hemoglobin continues without adequate nutritional intervention and iron replenishment, the condition transcends normal physiological limits and transforms into a severe pathological state known as iron deficiency anemia.

Anemia during pregnancy is clinically defined as a state where the maternal hemoglobin level drops below established physiological thresholds, specifically less than 11 g/dL during the first and third trimesters, or less than 10.5 g/dL during the second trimester. According to the World Health Organization (WHO), gestational anemia is further stratified into specific severity levels comprising mild anemia with hemoglobin levels ranging from 8 to 9.9 g/dL, moderate anemia between 6 and 7.9 g/dL, and severe anemia when the hemoglobin concentration falls below 6 g/dL. This clinical condition remains a major global public health concern that demands continuous epidemiological monitoring. Global health data from the WHO indicated that the prevalence of anemia among pregnant women worldwide reached 36.5% in 2021, increased to 37% in 2022, and showed a minimal reduction to 35.5% in 2023. Despite the minor reduction, these persistent figures highlight that anemia continues to

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threaten more than one-third of the global pregnant population, presenting significant clinical risks to maternal and fetal well-being.

In Indonesia, the prevalence of gestational anemia reflects a critical health crisis that closely mirrors these distressing global epidemiological trends. The Ministry of Health of the Republic of Indonesia reported that the prevalence of anemia among pregnant women was alarmingly high at 48.9% in 2021. Through intensive public health programs, this national rate was successfully lowered to 42.1% in 2022, and it continued to show a progressive decrease down to 27.7% in 2023 according to the Indonesian Health Survey (SKI). Although this downward trend reflects a positive structural advancement in maternal healthcare, a 27.7% prevalence rate indicates that iron deficiency remains widespread and requires more targeted clinical strategies. At the provincial level, North Sumatra exhibits an unstable and deeply concerning epidemiological pattern. Based on the North Sumatra Provincial Health Office Profile, the absolute number of gestational anemia cases rose sharply from 1,782 cases in 2022 to 6,532 cases in 2023, and peaked at 8,464 cases in 2024, demonstrating that maternal iron deficiency remains a growing regional threat.

Regionally, Deli Serdang Regency has consistently ranked among the top three territories with the highest absolute numbers of pregnant women suffering from anemia in North Sumatra over the last three years. In 2022 and 2023, the regency recorded 475 cases annually, positioning it first and third in provincial rankings, respectively. By 2024, the local burden increased drastically to 807 cases, marking Deli Serdang as the second highest in the province. Paradoxically, this high case rate persists despite excellent distribution networks for Iron-Folic Acid (IFA) supplements. Deli Serdang achieved an impressive 97.11% coverage rate for distributing standard iron tablets (TTD) in 2024, ranking 7th highest in North Sumatra. This sharp disconnect between high distribution coverage and rising anemia rates reveals that simply distributing supplements is insufficient, indicating that the root problem lies in low consumer compliance and poor physiological absorption of the distributed iron.

At the community level, preliminary data gathered from the Wonosari Village Auxiliary Health Post in Tanjung Morawa Subdistrict confirms this ongoing public health issue. The local records showed that the incidence of gestational anemia increased from 35.4% in 2024 (17 anemic mothers out of 48 pregnancies) to 38.46% in 2025 (20 anemic mothers out of 52 pregnancies). Furthermore, a preliminary survey conducted by the researcher on April 18, 2026, in Wonosari Village revealed that 4 out of 10 interviewed pregnant women remained highly anemic. Qualitative interviews with these women exposed severe gaps in health literacy. Many respondents admitted that they did not consume their iron tablets regularly due to gastrointestinal side effects like nausea and vomiting. Others frequently swallowed their iron tablets alongside tea, coffee, or milk—beverages rich in tannins and calcium that chemically bind iron and inhibit its absorption in the gut, preventing it from working effectively.

To overcome these bio-absorption barriers, combining iron supplements with an absorption enhancer like Vitamin C (ascorbic acid) offers a highly effective, evidence-based solution. Biochemically, Vitamin C plays a crucial role in enhancing the bioavailability of non-heme iron within the small intestine. It acts as a powerful reducing agent that chemically transforms iron from its insoluble ferric form (Fe^{3+}) into its highly soluble ferrous form (Fe^{2+}), which is easily absorbed by the intestinal mucosa. Additionally, Vitamin C forms a protective chelate complex with iron, shielding it from dietary inhibitors such as phytates and tannins. Clinical trials by Nike Ichwan Rahayu dkk. (2025) demonstrated that combined iron and Vitamin C therapy raised maternal hemoglobin by an average of 2.2 g/dL, outperforming iron-only supplementation ($p = 0{,}000$). Similarly, Sirlii Diana dkk. (2024) confirmed that this dual-supplement strategy significantly shifted the clinical distribution of patients out of the anemia category ($p = 0{,}038$), helping the majority of respondents achieve normal hemoglobin status.

While previous literature strongly supports the biochemical synergy of iron and Vitamin C, critical research gaps remain. Most existing studies focus purely on shifts in mean hemoglobin values without tracking detailed improvements across specific anemia severity categories. Furthermore, variations in research designs, geographical settings, and local socio-cultural compliance behaviors in rural communities can significantly alter interventional outcomes, creating a clear gap in localized empirical evidence. Therefore, this study titled "Effectiveness of Iron Tablets with Vitamin C on Increasing Hemoglobin Levels range among Pregnant Women in Wonosari Village, Tanjung Morawa Subdistrict, Deli Serdang Regency in 2026" is highly critical and urgently needed. This research is vital to provide a comprehensive empirical framework for local healthcare providers to transition from simple

distribution models to an optimized, absorption-focused maternal care strategy that enhances iron bioavailability at the grassroots level.

Based on the background described above, the primary research question is formulated as follows: Is the co-administration of iron (Fe) tablets with Vitamin C effective in increasing hemoglobin levels among pregnant women in Wonosari Village, Tanjung Morawa Subdistrict, Deli Serdang Regency in 2026. The general objective of this clinical study is to evaluate and determine the effectiveness of co-administering iron (Fe) tablets with Vitamin C on increasing maternal hemoglobin levels among pregnant women at the study site. To achieve this broad goal, the study is systematically directed toward several specific objectives, which include identifying the baseline hemoglobin levels of pregnant women prior to the co-administration of iron (Fe) tablets with Vitamin C, describing the post-interventional hemoglobin levels after the systematic administration of the combined therapy, and analyzing the statistical and clinical effectiveness of co-administering iron (Fe) tablets with Vitamin C on increasing maternal hemoglobin levels among the respondents in Wonosari Village.

The theoretical significance of this study lies in its valuable contribution to the development of maternal health and midwifery sciences by providing fresh empirical data regarding gestational hematology. It expands the existing conceptual literature on the physiological synergy between ascorbic acid and ferrous compounds, serving as a reliable scientific reference for future academic investigations into micronutrient bio-absorption. Practically, the findings serve as an essential empirical guide for local health facilities, including public clinics and village health posts, to restructure their antenatal care strategies from basic iron distribution to optimized, absorption-focused guidelines. For the respondents, this study acts as an educational tool to improve health literacy and empower pregnant women to adopt correct supplement consumption habits to protect themselves and their fetuses from the dangers of anemia. Finally, for academic institutions and future researchers, this research report offers a reliable baseline dataset that can be used to design broader experimental studies incorporating diverse nutritional, environmental, and maternal variables.

2. Literature Review

The physiological adaptation during pregnancy involves a profound alteration in the maternal homeostatic system to ensure adequate nutrient and oxygen delivery to the growing fetus. One of the most critical modifications occurs within the hematological system, characterized by a massive expansion of blood volume. This expansion serves several vital functions, including meeting the high metabolic demands of the hypertrophied uterus, supporting placental perfusion, and protecting the mother against blood loss during parturition. However, this adaptation triggers a distinct phenomenon known as physiological hemodilution. The mechanism of hemodilution stems from an imbalance between plasma expansion and erythrocyte production, where plasma volume increases by 40% to 45% while red blood cell mass only rises by 20% to 30%. Consequently, this dilution process causes a significant decrease in hemoglobin concentration and hematocrit values, which is often termed pseudoanemia or physiological anemia of pregnancy. If this decline is not compensated by adequate iron intake or maternal iron reserves, the physiological adaptation easily crosses the threshold into pathological iron deficiency anemia.

Gestational iron deficiency anemia develops sequentially when iron demand outpaces supply, severely disrupting the process of erythropoiesis. In the initial stage, iron depletion occurs quietly as maternal ferritin stores are exhausted to satisfy fetal requirements, though hemoglobin levels remain temporarily within the normal range. As the deficiency progresses to iron-deficient erythropoiesis, transferrin saturation drops, and the bone marrow lacks sufficient iron to synthesize heme, eventually culminating in frank iron deficiency anemia characterized by microcytic and hypochromic red blood cells. The etiology of this condition is multifactorial, primarily driven by inadequate dietary iron intake, close pregnancy spacing, teenage gestation, multiple pregnancies, or underlying infections that impair iron utilization. This pathological state leads to generalized tissue hypoxia due to the reduced oxygen-carrying capacity of the blood. The clinical manifestations range from mild fatigue, dizziness, and pallor to severe cardiovascular complications such as tachycardia and low blood pressure when hemoglobin levels fall below critical thresholds.

The occurrence of maternal anemia during pregnancy is strongly linked to severe clinical complications affecting both the mother and the developing fetus. For the mother, tissue hypoxia directly weakens the uterine muscle fibers, leading to a higher risk of abortus, preterm labor, and prolonged labor caused by uterine inertia. Furthermore, the lack of myometrial

contractility can cause uterine atony during the third stage of labor, significantly increasing the risk of severe postpartum hemorrhage, hypovolemic shock, and maternal mortality. Chronic hypoxia also impairs the maternal immune response and disrupts collagen synthesis, making the mother highly vulnerable to puerperal infections and causing complications like premature rupture of membranes. For the fetus, maternal anemia impairs placental growth and induces placental hypertrophy, kalsifikasi, or infark as a compensatory mechanism to capture limited oxygen. This placental insufficiency directly restricts the supply of oxygen and crucial nutrients to the fetus, leading to intra-uterine growth restriction (IUGR), low birth weight (LBW), low Apgar scores, neonatal asphyxia, and congenital anomalies.

To prevent these severe complications, standard antenatal care guidelines mandate iron supplementation, though its success is heavily limited by gastrointestinal absorption barriers. The standard program requires pregnant women to consume at least 90 tablets of iron-folic acid (IFA) throughout gestation, where each tablet contains ferrous sulfate providing approximately 60 mg of elemental iron. However, the oral administration of inorganic iron face severe absorption challenges within the duodenal brush border. Oral iron supplements are mostly in the non-heme ferric form (Fe^{3+}), which is highly insoluble and cannot be directly transported across the intestinal mucosa. Furthermore, its bioavailability is easily hindered by dietary inhibitors such as tannins in tea or coffee and calcium in milk, which bind with iron to form insoluble complexes in the gastrointestinal tract. Unabsorbed iron remains in the intestinal lumen, causing common side effects like nausea, vomiting, constipation, and dark stools, which frequently leads to poor patient compliance and interventional failure.

Co-administering iron supplements with Vitamin C (ascorbic acid) offers a vital biochemical solution to bypass these absorption barriers and maximize iron bioavailability. Vitamin C is a powerful antioxidant and an essential water-soluble nutrient that directly enhances the mucosal absorption of non-heme iron. The primary mechanism involves the reduction of insoluble ferric iron (Fe^{3+}) into the highly soluble ferrous form (Fe^{2+}) within the acidic environment of the stomach, making it a perfect substrate for the divalent metal transporter 1 (DMT1) in the enterocytes. Additionally, ascorbic acid acts as a protective chelating agent that binds with iron at an acidic pH, preventing it from interacting with dietary inhibitors like phytates and tannins in the duodenum. By maintaining iron in a soluble, absorbable form, Vitamin C significantly boosts its bio-absorption, shortens the required therapy period, and potentially reduces the amount of unabsorbed iron that causes gastrointestinal distress, thereby indirectly improving maternal compliance.

Several recent clinical studies have provided strong empirical evidence supporting the therapeutic superiority of this combined nutritional strategy. Research conducted by Nike Ichwan Rahayu dkk. (2025) using an experimental pre-test and post-test control group design involving 40 anemic pregnant women revealed that the combination of iron and Vitamin C produced a highly significant hemoglobin increase of 2.2 g/dL compared to only 0.9 g/dL in the iron-only control group ($p = 0.000$). This finding is closely supported by Sirlii Diana dkk. (2024), who applied a pre-experimental one-group pretest-posttest approach on 22 anemic pregnant women. Their study demonstrated that systematic iron and Vitamin C co-administration significantly shifted 59.1% of the anemic respondents into the normal hemoglobin category ($p = 0.038$). These consolidated studies confirm that optimizing iron absorption via ascorbic acid reduction is a reliable and clinically effective method to increase maternal hemoglobin levels and eradicate gestational anemia.

3. Materials and Method

This study utilizes a quantitative approach with a pre-experimental design to empirically evaluate the effectiveness of the intervention. The specific research design implemented is the One-Group Pretest-Posttest Design, which involves a single group of subjects observed before and after the clinical treatment. In this design, the maternal hemoglobin level is measured as the pretest baseline (O_1) before the respondents receive the intervention. The intervention (X) consists of the systematic co-administration of oral iron (Fe) tablets alongside Vitamin C supplements over a designated period. Following the completion of this interventional phase, a secondary measurement or posttest (O_2) is conducted using the exact same diagnostic tool to quantify any statistical and clinical changes in hemoglobin concentration. This design allows the researcher to analyze the immediate differences within the same subject group, making it highly appropriate for evaluating localized clinical interventions in maternal healthcare settings where establishing a strict control group is logistically or ethically restricted.

The operational framework of this study relies on clear definitions of both the independent and dependent variables to maintain empirical accuracy. The independent variable is defined as the co-administration of iron tablets and Vitamin C, which is measured through maternal compliance and recorded using a structural observation checklist. Respondents are categorized as compliant if they properly consume at least 80% of the prescribed dual supplements according to the designated dosage, timing, and clinical guidelines during the interventional period. Conversely, the dependent variable is the maternal hemoglobin concentration, representing the absolute amount of oxygen-carrying protein within the red blood cells, which is measured in grams per deciliter (g/dL). The clinical outcomes are further operationalized into distinct diagnostic categories: normal status ($\geq$ 11 g/dL), mild anemia (8.0–9.9 g/dL), moderate anemia (6.0–7.9 g/dL), and severe anemia ($<$ 6.0 g/dL). Additionally, the actual increase in hemoglobin is operationalized as a nominal scale based on the arithmetic difference between the pretest and posttest laboratory values.

The research was carried out in Wonosari Village, Tanjung Morawa Subdistrict, Deli Serdang Regency, North Sumatra Province, Indonesia. This specific location was selected due to its persistently high burden of gestational anemia despite wide distribution coverage of iron supplements. The study took place between March and July 2026, encompassing the initial field survey, ethical clearing, intervention administration, data gathering, and final statistical analysis. The target population included all pregnant women residing in Wonosari Village during the study timeframe, totaling 51 individuals. To obtain a representative and reliable sample, the researcher utilized a purposive sampling technique based on strict clinical criteria. The inclusion criteria required respondents to be permanent residents of Wonosari Village, officially registered in the local maternal healthcare system, willing to sign the informed consent, and committed to following the iron-Vitamin C regimen. The exclusion criteria filtered out pregnant women with chronic disorders like thalassemia, severe cardiac or renal diseases, those taking other conflicting micronutrient supplements, or those facing severe obstetric complications during the study. Applying these criteria resulted in a final sample size of 39 respondents.

Data collection was executed systematically through multiple steps to guarantee the validity of the laboratory and behavioral data. In the initial phase, the researcher approached eligible pregnant women, explained the study procedures, risks, and benefits, and obtained their signed informed consent. Next, the baseline pretest hemoglobin level was measured using a digital point-of-care testing (POCT) hemoglobin meter, specifically the Easy Touch device, by drawing capillary blood under strict standard operating procedures. The respondents were then provided with iron tablets paired with Vitamin C supplements and instructed on proper intake methods. Throughout the interventional phase, the researcher closely monitored maternal compliance using a structural observation checklist to track the daily frequency and correct consumption of the supplements. At the end of the intervention, a posttest hemoglobin measurement was performed using the exact same digital POCT device and laboratory protocol. The primary data from these laboratory tests and observation sheets were securely compiled alongside secondary data regarding local maternal demographics from the village health post.

The collected data underwent statistical processing through univariat and bivariat analyses using computerized statistical software. Univariat analysis was applied to describe the distribution and frequency of maternal characteristics, compliance rates, and hemoglobin categories before and after the intervention. These descriptive statistics are presented through frequency tables, percentages, means, minimum-maximum values, and standard deviations. Before testing the main hypothesis, a data normality test was performed using the Shapiro-Wilk test due to the small sample size ($n = 39$). Since the hemoglobin values followed a normal distribution, bivariat analysis was conducted using the Paired Sample t-Test to evaluate the mean differences between the pretest and posttest measurements. The statistical decision-making was based on a significance threshold of $\alpha = 0.05$. A resulting p-value lower than 0.05 rejects the null hypothesis (H_0), confirming that the combined iron and Vitamin C intervention is statistically effective in increasing maternal hemoglobin levels.

The study strictly adhered to core bioethical principles to protect the human rights and safety of all participants. The principle of respect for persons was maintained by ensuring that participation was entirely voluntary; all respondents received extensive explanations and signed an informed consent form without any form of coercion. To protect anonymity, the researcher used confidential coding systems instead of personal names on all research instruments and master tables. The principles of beneficence and non-maleficence were

carefully maintained by ensuring that the combined nutritional doses were completely safe, non-invasive except for the minor capillary puncture, and designed to maximize therapeutic advantages while minimizing gastrointestinal side effects. Finally, the principle of justice was fulfilled by providing identical interventional supplements, health education, and diagnostic monitoring to all participating pregnant women without any discrimination based on their socioeconomic or cultural background.

4. Results and Discussion

Overview of the Study Site

This research was systematically conducted within Wonosari Village, which is located in the Tanjung Morawa Subdistrict of the Deli Serdang Regency in North Sumatra Province. The village represents a developing rural-suburban area where the local population predominantly relies on agriculture, local trade, and micro-entrepreneurship for their livelihoods. In terms of maternal healthcare infrastructure, Wonosari Village is officially supported by the Tanjung Morawa Public Health Center through a functioning Village Auxiliary Health Post (*Puskesmas Pembantu* or Pustu), alongside dedicated village midwives (*Bidan Desa*) and active community health volunteers (*Kader Kesehatan*). These local health workers routinely collaborate to run integrated health posts (*Posyandu*), manage maternal and child health programs, monitor gestational nutrition, and distribute government-subsidized Iron-Folic Acid tablets to prevent gestational anemia.

Research Findings

The primary data gathered from this pre-experimental study were statistically processed to evaluate the exact changes in maternal hemoglobin levels before and after the clinical intervention. The complete data set was extracted from a sample size of 39 pregnant women who fully satisfied all the inclusion and exclusion criteria throughout the longitudinal monitoring period. The laboratory findings and behavioral tracking records were subjected to univariat descriptive analysis and bivariat inferential testing using standardized computerized statistical software.

Univariat Analysis

Univariat analysis was initially conducted to establish a clear descriptive profile of the respondents' hemoglobin values prior to and following the nutritional intervention. Before the co-administration of oral iron tablets and Vitamin C, the baseline clinical data revealed that out of the 39 participating pregnant women, a majority of 26 individuals (66.65%) maintained a normal hemoglobin concentration of ≥ 11 g/dL. However, a substantial portion of the sample, consisting of 13 pregnant women (33.35%), suffered from mild anemia with hemoglobin values ranging strictly between 8.0 and 9.9 g/dL. Descriptive tracking showed that the lowest baseline hemoglobin recorded was 8.3 g/dL, while the highest was 13.0 g/dL. No respondents were identified as suffering from moderate anemia (6.0–7.9 g/dL) or severe anemia (< 6.0 g/dL) at the pretest stage.

Tabel 1. Distribusi Kadar Hemoglobin Sebelum Pemberian Tablet Zat Besi dan Vitamin C (*Pre-test*)

No	Kategori Anemia	Kadar Hb (g/dL)	Frekuensi (f)	Persentase (%)
1.	Normal	≥ 11,0	26	66,65%
2.	Anemia Ringan	8,0 – 9,9	13	33,35%
3.	Anemia Sedang	6,0 – 7,9	0	0,00%
4.	Anemia Berat	< 6,0	0	0,00%
Jumlah			**39**	**100,00%**

Source: Analyzed Primary Data, 2026

Tabel 2. Distribusi Kadar Hemoglobin Setelah Pemberian Tablet Zat Besi dan Vitamin C (*Post-test*)

No	Kategori Anemia	Kadar Hb (g/dL)	Frekuensi (f)	Persentase (%)
1.	Normal	≥ 11,0	38	97,43%
2.	Anemia Ringan	8,0 – 9,9	1	2,57%
3.	Anemia Sedang	6,0 – 7,9	0	0,00%
4.	Anemia Berat	< 6,0	0	0,00%
Jumlah			**39**	**100,00%**

Source: Analyzed Primary Data, 2026

Tabel 3. Nilai Statistik Deskriptif Kadar Hemoglobin Responden ($n = 39$)

Variabel	Nilai Minimum	Nilai Maksimum	Rata-rata (Mean)	Standar Deviasi (SD)
Hb Sebelum Intervensi	8,3 g/dL	13,0 g/dL	11,21 g/dL	1,12
Hb Sesudah Intervensi	10,9 g/dL	15,2 g/dL	13,60 g/dL	0,98
Peningkatan Hb	**0,3 g/dL**	**4,1 g/dL**	**2,39 g/dL**	**0,54**

Source: Analyzed Primary Data, 2026

Following the systematic implementation of the intervention, where the respondents consumed their daily iron tablets combined with Vitamin C supplements under checklist-based observation, a secondary posttest measurement was conducted. The posttest laboratory results demonstrated a profound upward shift in maternal hemoglobin distribution across the sample. Specifically, the number of pregnant women with normal hemoglobin levels surged to 38 individuals, accounting for 97.43% of the total sample. Conversely, the prevalence of mild anemia dropped dramatically, leaving only 1 respondent (2.57%) within the anemic category. Posttest descriptive statistics showed that the minimum hemoglobin level rose to 10.9 g/dL, while the maximum value achieved was 15.2 g/dL. Similar to the pretest findings, there were zero cases of moderate or severe anemia detected among the respondents after the trial. This marked difference between the pretest and posttest distributions clearly demonstrates an absolute reduction in the local burden of gestational anemia within the studied community.

Bivariat Analysis

To verify whether the observed increase in maternal hemoglobin was statistically significant, a bivariat inferential analysis was performed using the Paired Sample t-Test. The prerequisite normality testing via the Shapiro-Wilk protocol confirmed that the continuous hemoglobin data followed a normal distribution, thus justifying the application of parametric statistics. The arithmetic evaluation showed that the mean hemoglobin concentration rose from 11.21 g/dL at the pretest to 13.60 g/dL at the posttest, yielding a substantial mean absolute increase of 2.39 g/dL across the sample.

The inferential calculation using the Paired Sample t-Test generated a two-tailed significance value of $p < 0.000$. Because this resulting p-value is significantly lower than the standard alpha threshold ($\alpha = 0.05$), the null hypothesis (H_0) is definitively rejected, and the alternative hypothesis (H_1) is accepted. This mathematical outcome proves that there is a highly significant statistical and clinical difference between the maternal hemoglobin levels measured before and after the nutritional treatment. Consequently, it can be scientifically concluded that the co-administration of oral iron tablets alongside Vitamin C is highly effective in elevating hemoglobin levels among pregnant women in Wonosari Village.

Table 4. Paired Sample t-Test Results for Maternal Hemoglobin Levels Before and After Intervention ($n = 39$)

Hemoglobin Measurement	Mean (g/dL)	Mean Difference (g/dL)	Standard Deviation (SD)	p-value	Statistical Decision
Pretest (Before Intervention)	**11.21**	**2.39**	**0.54**	**< 0.000**	**Reject H_0 / Significant ($p < 0.05$)**
Posttest (After Intervention)	**13.60**				

Source: Analyzed Primary Data, 2026

Discussion

The empirical findings of this study confirm that the co-administration of oral iron tablets and Vitamin C successfully addresses the physiological and behavioral barriers that often cause standard iron distribution programs to fail. The baseline data showed that about one-third of the pregnant women in Wonosari Village were anemic prior to the study. This mirrors

the broader epidemiological issues highlighted in the North Sumatra health profiles, where gestational anemia cases have risen sharply from year to year. This initial vulnerability is driven by two main factors: the natural process of physiological hemodilution, where maternal plasma volume expands much faster than red blood cell mass, and poor dietary and supplement habits at the community level. The preliminary interviews exposed that many local women lacked proper health literacy, often taking their iron supplements with inhibitors like tea or coffee, or stopping altogether due to gastrointestinal side effects.

The posttest results demonstrate that this combined nutritional strategy successfully overcomes these challenges, with 97.43% of the respondents achieving normal hemoglobin status. This significant clinical improvement is rooted in the biochemical synergy between ferrous iron and ascorbic acid. Vitamin C serves as a crucial reducing agent within the gastrointestinal tract, chemically transforming insoluble ferric iron (Fe^{3+}) into its highly soluble ferrous form (Fe^{2+}), which the intestinal mucosa can easily absorb. Furthermore, by binding with iron to form a stable chelate complex, Vitamin C protects the mineral from interacting with dietary inhibitors like tannins and calcium. This enhanced bio-absorption maximizes erythropoiesis in the bone marrow, enabling efficient hemoglobin synthesis that counteracts the dilutional effects of pregnancy. Additionally, using an observation checklist helped reinforce daily compliance, ensuring that respondents took their supplements regularly and correctly.

Statistically, the highly significant absolute increase of 2.39 g/dL ($p < 0.000$) aligns closely with recent maternal health literature. It directly matches the experimental findings of Nike Ichwan Rahayu dkk. (2025), who recorded a similar mean hemoglobin increase of 2.2 g/dL ($p = 0.000$) among pregnant women using combined iron and Vitamin C therapy. It also supports the clinical trends observed by Sirlii Diana dkk. (2024), where a dual-supplement regimen effectively resolved mild and moderate anemia in the majority of treated subjects ($p = 0.038$). By demonstrating both statistical significance and concrete shifts across clinical categories, this study provides solid empirical evidence that optimizing iron absorption through ascorbic acid reduction is a reliable strategy to eliminate gestational anemia and safeguard maternal and fetal health.

5. Conclusion

Based on the empirical findings and comprehensive statistical analysis of this study evaluating the co-administration of oral iron tablets and Vitamin C among pregnant women in Wonosari Village, Tanjung Morawa Subdistrict, Deli Serdang Regency in 2026, several definitive conclusions can be drawn. First, the baseline maternal hemoglobin levels measured prior to the clinical intervention revealed that a substantial portion of the population remained vulnerable to iron deficiency anemia. Out of the 39 participating pregnant women, 33.35% (13 individuals) were diagnosed with mild gestational anemia, while the remaining 66.65% (26 individuals) fell within the normal physiological range. This baseline vulnerability highlights that standard dietary intake and distributed iron pills alone were insufficient to meet the heightened hematological demands of pregnancy or counteract normal physiological hemodilution within this community.

Second, the secondary laboratory measurements taken after the implementation of the combined nutritional regimen showed a profound positive change in the overall distribution of maternal hemoglobin levels. Following the trial, the proportion of healthy respondents rose to 97.43% (38 individuals), while the prevalence of mild anemia dropped significantly to just 2.57% (1 individual). This marked shift across clinical categories proves that the systematic intake of Vitamin C alongside iron supplements successfully helps the majority of respondents recover from anemia and maintain optimal blood iron status.

Third, the inferential statistical analysis confirmed that the intervention provides a highly significant clinical advantage. The continuous hemoglobin concentration rose from a pretest mean of 11.21 g/dL to a posttest mean of 13.60 g/dL, achieving a substantial absolute mean increase of 2.39 g/dL across the sample. The mathematical calculations using the Paired Sample t-Test yielded a significance value of $p < 0.000$, which safely rejects the null hypothesis (H_0) and validates the alternative hypothesis (H_1). In summary, this study scientifically proves that the co-administration of oral iron tablets alongside Vitamin C is highly effective in increasing maternal hemoglobin levels. This combined strategy effectively overcomes intestinal absorption barriers by utilizing ascorbic acid to reduce iron into an absorbable state and prevent the negative effects of dietary inhibitors.

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