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The Effectiveness of Multiple Micronutrient Supplementation (MMS) in Reducing Anemia Among Pregnant Women at the Siwalan Community Health Center in Pekalongan Regency in 2026

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Abstract

Anemia during pregnancy remains an important public health problem because it can increase the risk of maternal and fetal complications. Multiple Micronutrient Supplementation (MMS), which contains various vitamins and minerals involved in hemoglobin synthesis and erythropoiesis, represents an approach to improving maternal micronutrient status and reducing anemia. This study aimed to determine the effectiveness of MMS administration in reducing anemia among pregnant women at Siwalan Community Health Center, Pekalongan Regency, in 2026. An empirical quantitative study was conducted using a pre-experimental one-group pretest–posttest design involving 38 pregnant women selected through purposive sampling. Hemoglobin concentrations and anemia status were assessed before and after 30 days of MMS administration through routine antenatal care services. Data were analyzed using the paired t-test for changes in hemoglobin concentration and the McNemar test for changes in anemia status at a 95% confidence level. The proportion of anemic participants decreased from 17 women (44.7%) before intervention to 6 women (15.8%) after intervention, while mean hemoglobin concentration increased from 11.345 ± 1.134 g/dL to 12.268 ± 1.182 g/dL. The paired t-test demonstrated a statistically significant increase in hemoglobin concentration ($p < 0.001$), and the McNemar test indicated a significant change in anemia status ($p = 0.001$). MMS administration was associated with improved hemoglobin levels and reduced anemia among pregnant women. These findings support MMS implementation as part of integrated antenatal services while recognizing the need for controlled studies to strengthen causal inference.

Keywords: *Anemia, Hemoglobin, Multiple Micronutrient Supplementation, Pregnancy, Pregnant Women.*

INTRODUCTION

Anemia in pregnancy remains one of the most important maternal and public health challenges because inadequate hemoglobin status can compromise maternal physiological adaptation, fetal development, and pregnancy outcomes across diverse health systems. Anemia during pregnancy is commonly defined by hemoglobin (Hb) concentrations below 11 g/dL in the first and third trimesters and below 10.5 g/dL in the second trimester, with iron deficiency and inadequate availability of other hematopoietic micronutrients representing major nutritional pathways underlying the condition (Kementerian Kesehatan Republik Indonesia, 2023). The clinical consequences extend beyond reduced oxygen-carrying capacity, encompassing maternal fatigue, susceptibility to infection, postpartum hemorrhage, preterm birth, low birth weight, impaired fetal growth, and increased maternal and neonatal morbidity and mortality. At the global level, anemia continues to affect a substantial proportion of pregnant women, indicating that improvements in antenatal coverage alone have not eliminated the nutritional and biological determinants of maternal anemia (World Health Organization, 2025). The persistence of the problem has increasingly shifted scientific attention from iron deficiency alone toward integrated micronutrient strategies capable of addressing multiple nutritional requirements during pregnancy. Evidence from international guidance has consequently positioned multiple micronutrient supplementation (MMS) as an intervention of potential relevance to maternal nutritional status, particularly where deficiencies coexist and conventional iron–folic acid supplementation may not adequately address the broader micronutrient burden (World Health Organization, 2020). This

broader nutritional perspective is particularly important in settings where maternal anemia remains prevalent despite the established availability of antenatal supplementation programs.

The burden of maternal anemia is particularly concerning in Indonesia, where substantial regional variation suggests that national averages may conceal persistent problems at subnational and primary-care levels. In Indonesia, anemia among pregnant women has been reported at 29.4%, while the prevalence in Central Java has reached 55.8%, demonstrating the continuing difficulty of achieving equitable maternal nutritional health across regions (Dinas Kesehatan Provinsi Jawa Tengah, 2025). At the district level, the prevalence of anemia among pregnant women in Pekalongan Regency was reported at 34.1%, indicating that the problem remains clinically relevant within the local maternal health system (Dinas Kesehatan Kabupaten Pekalongan, 2026). Within the working area of the Siwalan Community Health Center, anemia was still recorded among 23.1% of pregnant women based on the 2025 Maternal and Child Health Program report, providing an important local signal of unresolved nutritional risk. The persistence of anemia despite established antenatal interventions indicates that program availability and intervention exposure do not necessarily translate into sufficient biological effectiveness. Indonesian maternal health policy has incorporated routine antenatal care, hemoglobin monitoring, iron supplementation, nutritional education, and maternal health documentation as interconnected strategies for anemia prevention and management (Kementerian Kesehatan Republik Indonesia, 2024a). The introduction of standardized micronutrient supplementation for pregnant women further reflects a policy transition toward broader nutritional support rather than reliance exclusively on conventional iron–folic acid supplementation (Kementerian Kesehatan Republik Indonesia, 2024b).

The principal challenge in existing anemia-control programs concerns not merely the availability of supplements but the extent to which pregnant women can consistently consume and tolerate them throughout pregnancy. Conventional iron supplementation can be undermined by gastrointestinal discomfort, nausea, vomiting, constipation, dizziness, and other adverse experiences that reduce adherence and subsequently weaken the expected hematological response (Kementerian Kesehatan Republik Indonesia, 2023). Recent Indonesian evidence indicates that adherence to MMS consumption is also shaped by educational exposure and communication interventions, suggesting that supplementation effectiveness is partly dependent on behavioral and implementation conditions rather than nutrient composition alone (Islami & Maulina, 2026). Maternal knowledge, education, and family support have similarly been associated with compliance with MMS consumption, reinforcing the importance of considering supplementation as a behaviorally mediated intervention within antenatal care (Yuriani & Maulina, 2025). These findings challenge a purely biomedical interpretation in which the provision of a nutritionally superior formulation is automatically expected to produce a corresponding reduction in anemia. International evidence indicates that MMS may offer advantages over iron–folic acid supplementation, although the magnitude of hematological benefit can vary according to iron dose, baseline nutritional status, adherence, and population characteristics (Gomes et al., 2022). The acceptability of MMS compared with conventional supplementation is also increasingly recognized as an implementation determinant because women's perceptions of formulation, tolerability, and perceived benefits can influence continued use during pregnancy (Kissell et al., 2025). The effectiveness question therefore requires assessment under actual service-delivery conditions in which biological efficacy interacts with adherence, counseling, maternal characteristics, and routine antenatal practices.

MMS represents an important development in maternal nutrition because it combines multiple vitamins and minerals required for erythropoiesis, hemoglobin synthesis, cellular metabolism, and broader maternal–fetal physiological processes within a single supplementation strategy. The UNIMMAP formulation contains 15 essential vitamins and minerals, including iron, folic acid, vitamin B-complex components, vitamins C and D, vitamin A, zinc, selenium, copper, and iodine, providing a more comprehensive micronutrient profile than conventional iron–folic acid supplementation (United Nations International Multiple Micronutrient Preparation, 2023). Systematic evidence has increasingly supported the potential of MMS to improve maternal anemia outcomes, while also indicating that its relative advantage over iron–folic acid may depend on the amount of iron provided and the nutritional context of the population (Alfiani et al., 2025). Indonesian empirical studies have reported improvements in hemoglobin following MMS administration, including evidence from pregnant women receiving MMS through community-based maternal health services (Lestari & Heryani, 2025).

Quasi-experimental evidence has likewise demonstrated changes in anemia status following MMS administration, strengthening the biological plausibility of MMS as an intervention for maternal anemia (Katili, 2025). Local implementation studies have further shown that MMS distribution accompanied by nutritional education can be incorporated into primary healthcare services, although evidence of service feasibility does not necessarily establish the magnitude of its hematological effectiveness (Dewiyanti Fitria et al., 2025). MMS implementation in Pekalongan Regency since 2024 and at the Siwalan Community Health Center since May 2025 provides a policy and service context in which the effectiveness of this intervention can be evaluated under routine antenatal conditions rather than solely within controlled research environments.

Despite the growing evidence base, important empirical and conceptual gaps remain regarding whether the benefits demonstrated in controlled or geographically distinct settings are reproduced when MMS is integrated into routine primary healthcare services in Indonesia. Evidence from Pregnant women in Telaga Biru and Pare-Pare has indicated increases in hemoglobin following MMS supplementation, yet these findings originate from specific local populations whose nutritional, behavioral, and healthcare contexts may differ from those of pregnant women receiving routine care in Siwalan (Meiyanti, 2024; Subair, 2023). A retrospective cohort study from another population reported that MMS was associated with reduced risk of anemia during pregnancy, strengthening the broader epidemiological evidence but leaving questions regarding implementation effectiveness in Indonesian primary-care settings (Zhong et al., 2025). Recent research has also expanded toward dose optimization, as demonstrated by an individually randomized trial comparing different iron doses within MMS formulations, indicating that the hematological effect of MMS cannot be interpreted independently of supplementation composition and dose (Smith et al., 2025). Evidence concerning maternal acceptance in Indonesia similarly demonstrates that willingness to use MMS is not uniform, suggesting that implementation outcomes may influence the degree to which nutritional efficacy is translated into measurable clinical benefit (Alfaqeeh et al., 2025). Studies examining acceptance at the local level have further shown that women's experiences and perceptions can shape the feasibility of sustained MMS utilization, reinforcing the need for context-specific evaluation rather than assuming uniform intervention performance across populations (Puspitasari et al., 2026). A further limitation is that some available Indonesian studies emphasize associations, knowledge, acceptance, or controlled intervention effects, while relatively limited evidence directly evaluates changes in hemoglobin and anemia status following MMS implementation as part of routine antenatal services at the community health-center level.

The unresolved evidence gap has both scientific and practical significance because a supplementation strategy that demonstrates efficacy under research conditions may produce different outcomes when delivered through routine services characterized by heterogeneous adherence, maternal characteristics, counseling exposure, and follow-up intensity. Existing reviews have emphasized the broader clinical benefits and safety considerations of MMS across preconception, pregnancy, and lactation, but the translation of these benefits into measurable improvements within specific primary-care populations remains insufficiently characterized (Liu et al., 2025). The evidence from Indonesia also suggests that the implementation context deserves greater attention because maternal acceptance and behavioral compliance may determine whether the biological potential of MMS is realized in practice. The Siwalan Community Health Center therefore represents a relevant empirical setting for examining whether the introduction of MMS into routine antenatal care corresponds with measurable improvements in maternal hemoglobin and reductions in anemia. This study is positioned within the emerging implementation-oriented literature by moving beyond the question of whether MMS can work under controlled conditions toward the more practice-relevant question of whether MMS is effective when delivered within an existing primary healthcare program. The study aims to evaluate the effectiveness of MMS supplementation in reducing anemia and improving hemoglobin levels among pregnant women receiving antenatal care at the Siwalan Community Health Center in Pekalongan Regency in 2026. By generating locally grounded empirical evidence, the study contributes theoretically by strengthening understanding of how a multi-micronutrient intervention operates within the interaction between nutritional supplementation and routine maternal healthcare, while contributing methodologically by providing a pre–post evaluation framework for assessing changes in anemia status under real-world primary-care conditions.

RESEARCH METHODS

This study employed an empirical quantitative approach using a pre-experimental one-group pretest–posttest design to evaluate changes in hemoglobin levels and anemia status before and after Multiple Micronutrient Supplementation (MMS). The participants were pregnant women receiving antenatal care at Siwalan Community Health Center, Pekalongan Regency, during the 2026 study period. Participants were selected using purposive sampling, with inclusion criteria comprising pregnant women receiving antenatal care at Siwalan Community Health Center, willing to participate in MMS supplementation and both pretest and posttest hemoglobin examinations, and having complete study data. Exclusion criteria included pregnant women who did not complete the MMS supplementation period, failed to undergo the post-intervention hemoglobin examination, or had medical conditions that could directly affect hemoglobin levels and potentially confound the interpretation of the supplementation effect. The selection of participants and implementation of the intervention were aligned with the maternal micronutrient supplementation framework, which recognizes MMS as a source of multiple vitamins and minerals required to support nutritional needs during pregnancy (United Nations International Multiple Micronutrient Preparation, 2023). Data were collected through hemoglobin examination before MMS administration as the pretest, followed by MMS supplementation delivered through routine antenatal services, and a subsequent hemoglobin examination as the posttest after the predetermined intervention period. This procedure enabled longitudinal assessment of hematological changes within the same participants under routine primary healthcare conditions.

The research instruments consisted of a participant characteristics form, an MMS administration or consumption monitoring sheet, and a hemoglobin measurement device used to obtain objective data on participants' hematological status. Hemoglobin concentrations were recorded in g/dL and served as the primary indicator for assessing changes in anemia status before and after supplementation. The use of hemoglobin concentration as an indicator is consistent with the national approach to monitoring and preventing anemia among pregnant women (Kementerian Kesehatan Republik Indonesia, 2023). Descriptive analysis was conducted to summarize participant characteristics and the distribution of hemoglobin levels and anemia status at baseline and post-intervention measurements. Differences in mean hemoglobin levels before and after MMS supplementation were analyzed using the paired t-test, as measurements were obtained from the same participants, whereas changes in categorical anemia status before and after the intervention were analyzed using the McNemar test. All statistical tests were conducted at a 95% confidence level with a significance threshold of $p < 0.05$ to determine whether the observed changes were statistically significant. The study received ethical approval from the Health Research Ethics Committee (KEPK) of Universitas Pekalongan through Ethical Clearance No. 148/B.02.01/KEPK/V/2026, issued on May 13, 2026, and the research procedures adhered to informed consent, confidentiality, voluntary participation, and participants' right to withdraw from the study.

RESULTS AND DISCUSSION

Characteristics of Respondents

The characteristics of the 38 pregnant women included in the study provide an important contextual basis for interpreting the subsequent hematological response to Multiple Micronutrient Supplementation (MMS). As presented in Table 1, the majority of participants were aged 20–35 years, comprising 30 women (78.9%), whereas 8 women (21.1%) were younger than 20 or older than 35 years. The predominance of participants within the 20–35-year age group indicates that the study population was largely within the age range generally considered favorable for pregnancy and reproductive health. Maternal age is relevant to nutritional and obstetric assessment because pregnancies occurring at younger or older ages may involve different physiological demands and risks that can influence maternal health status. The distribution of parity also showed a relatively balanced composition, although multiparous women were slightly more prevalent, with 20 participants (52.6%) compared with 18 primiparous women (47.4%). This composition provides a useful basis for interpreting the effectiveness of MMS because previous pregnancy experience may influence women's familiarity with antenatal care, nutritional recommendations, and supplement consumption.

Table 1. Characteristics of Respondents at Siwalan Community Health Center, Pekalongan Regency (n=38)

Characteristic	Frequency (f)	Percentage (%)
Age		
<20 and >35 years	8	21.1
20–35 years	30	78.9
Parity		
Primipara	18	47.4
Multipara	20	52.6
Total	**38**	**100**

The concentration of respondents in the 20–35-year category suggests that the observed changes in hemoglobin occurred predominantly among pregnant women within an age range that is generally associated with lower obstetric risk than pregnancies at the extremes of reproductive age. This distribution is relevant because maternal age can interact with nutritional requirements, physiological adaptation to pregnancy, and the occurrence of pregnancy-related complications. Previous evidence concerning MMS implementation has similarly demonstrated that pregnant women receiving supplementation are not a homogeneous population, and demographic characteristics may shape their experiences with supplementation and antenatal services (Alfaqeeh et al., 2025). The relatively small proportion of women outside the 20–35-year range means that the present findings should be interpreted primarily in relation to women of reproductive age rather than generalized equally across all maternal age groups. The predominance of multiparous participants also indicates that more than half of the sample had previous experience with pregnancy and childbirth. Such experience may facilitate recognition of the importance of antenatal visits and supplementation, although parity itself cannot be assumed to establish better adherence without direct measurement of compliance. The demographic profile therefore functions primarily as contextual information for interpreting the subsequent changes in hemoglobin rather than as evidence that age or parity independently determined the effectiveness of MMS.

From a maternal nutrition perspective, the age profile of the participants may provide a relatively stable physiological context for evaluating the intervention because most women were neither adolescents nor of advanced maternal age. Pregnancy nevertheless produces substantial changes in maternal blood volume and micronutrient requirements, meaning that women within the apparently favorable reproductive-age category can still experience anemia when nutritional demands are not adequately met. The national maternal health framework emphasizes continuous nutritional monitoring and prevention of anemia throughout pregnancy rather than restricting attention to women with identifiable demographic risk factors (Kementerian Kesehatan Republik Indonesia, 2024a). Parity introduces another contextual dimension because previous pregnancies may affect maternal nutritional reserves, although the direction and magnitude of this relationship depend on interpregnancy intervals, dietary intake, breastfeeding history, and overall maternal health. In the present sample, the difference between multiparous and primiparous women was modest, with multiparous participants exceeding primiparous participants by only two women. This relatively balanced distribution reduces the possibility that the overall findings were numerically dominated by one parity category. Nevertheless, the absence of detailed information on interpregnancy interval and previous anemia limits the extent to which parity-related nutritional depletion can be evaluated in this study.

The predominance of multiparous women may also have practical implications for MMS implementation because previous experience with pregnancy can shape familiarity with health-worker recommendations and supplementation routines. Research conducted in Indonesia has shown that adherence to MMS is influenced by individual knowledge, educational exposure, and family support, indicating that demographic characteristics alone do not sufficiently explain supplementation behavior (Yuriani & Maulina, 2025). This perspective is important for interpreting the present sample because the high proportion of women with previous pregnancy experience does not necessarily mean that all participants possessed adequate knowledge or demonstrated consistent MMS consumption. Evidence from primary healthcare implementation has also indicated that distribution of MMS accompanied by nutritional education can become integrated into antenatal services, making the quality of counseling

and monitoring relevant to intervention uptake (Dewiyanti Fitria et al., 2025). The demographic profile in Table 1 therefore supports the interpretation that the intervention was implemented among a predominantly reproductive-age population with substantial previous obstetric experience. At the same time, the relatively small number of women outside the 20–35-year group limits comparisons between maternal age categories. Similar caution applies to parity because the study was not designed or powered to test whether primiparity or multiparity modified the effect of MMS.

The respondent profile also provides an important foundation for interpreting the hematological outcomes reported in the subsequent analysis. Because 78.9% of participants were aged 20–35 years and 52.6% were multiparous, the observed improvement following MMS primarily reflects the response of women within these demographic groups rather than a balanced representation of all reproductive-age categories. Previous Indonesian research on MMS has likewise involved pregnant women with varying maternal characteristics, supporting the relevance of describing age and parity when evaluating intervention outcomes in local populations (Subair, 2023). The characteristics presented in Table 1 do not, however, establish a causal relationship between age, parity, and the response to MMS because no stratified inferential analysis was conducted for these variables. Their principal analytical value lies in identifying the population context in which the intervention was delivered and in assisting readers to assess the transferability of the findings. The relatively high representation of women in the 20–35-year range may facilitate interpretation of the intervention under conditions that are common within routine antenatal populations. Future studies could strengthen this evidence by examining whether age, parity, nutritional status, gestational age, and adherence interact to influence hematological responses to MMS. Such an approach would provide a more comprehensive understanding of individual variability in the effectiveness of micronutrient supplementation.

Hemoglobin Levels Before MMS Intervention

Before the MMS intervention, the distribution of hemoglobin status indicated that anemia remained a substantial problem among the pregnant women enrolled at Siwalan Community Health Center. Among the 38 participants, 17 women (44.7%) were classified as anemic, while 21 women (55.3%) were classified as not anemic. Although the proportion of participants without anemia was slightly higher, the finding that nearly one in two pregnant women presented with anemia indicates a considerable baseline hematological burden within the study population. This condition is clinically important because pregnancy increases the physiological requirements for iron and other micronutrients involved in erythropoiesis, maternal adaptation, placental development, and fetal growth. The baseline condition provides an essential reference for evaluating whether subsequent changes in hemoglobin concentration and anemia status occurred after MMS administration. The presence of both anemic and non-anemic participants also allows the intervention to be evaluated through changes in continuous hemoglobin levels as well as categorical anemia status.

The baseline prevalence observed in this study is particularly relevant within the broader Indonesian maternal health context, where anemia remains a persistent concern despite the availability of antenatal screening and supplementation programs. National guidance emphasizes early detection and prevention of maternal anemia because inadequate hemoglobin concentration may impair oxygen transport and increase the risk of adverse maternal and fetal outcomes (Kementerian Kesehatan Republik Indonesia, 2023). The proportion of anemic participants in the present study indicates that routine antenatal contact does not necessarily eliminate maternal anemia at the primary healthcare level. This condition may reflect the interaction of physiological demands, dietary adequacy, nutritional reserves, supplement consumption, and other maternal characteristics. The finding is also consistent with the continuing burden of maternal anemia reported at the provincial level in Central Java (Dinas Kesehatan Provinsi Jawa Tengah, 2025). The baseline profile therefore establishes a clinically relevant context for assessing whether the introduction of MMS within routine antenatal services is accompanied by measurable improvement in maternal hematological status.

Table 2. Hemoglobin Level Before MMS Intervention at Siwalan Community Health Center, Pekalongan Regency in May 2026 (n=38)

Hemoglobin Level	Frequency (f)	Percentage (%)
Anemia	17	44.7

Not Anemic	21	55.3
Total	**38**	**100.0**

The biological interpretation of the baseline anemia requires consideration of the substantial physiological adaptations occurring during pregnancy. Expansion of maternal plasma volume produces physiological hemodilution, while the increase in erythrocyte mass generates additional requirements for iron and other nutrients involved in red blood cell production. When dietary intake and maternal nutrient reserves are insufficient to meet these demands, hemoglobin synthesis may become inadequate and anemia can develop. Iron deficiency represents an important pathway, although folate, vitamin B12, vitamin C, and other micronutrients also contribute to normal erythropoiesis and iron utilization. The broader nutritional approach is consistent with WHO recommendations that recognize multiple micronutrient supplementation as a strategy for improving maternal nutritional adequacy during pregnancy (World Health Organization, 2020). The baseline data should therefore not be interpreted as evidence of iron deficiency alone because biochemical markers of iron stores and other micronutrient deficiencies were not measured in this study. This distinction supports the rationale for evaluating MMS as a comprehensive supplementation strategy rather than attributing maternal anemia exclusively to inadequate iron intake.

The proportion of anemia at baseline also highlights the importance of behavioral and implementation factors in maternal supplementation programs. The provision of supplements through antenatal services does not guarantee consistent consumption, because adherence may be influenced by maternal knowledge, perceived benefits, adverse effects, family support, and the quality of counseling received from healthcare providers. Indonesian research has demonstrated that information, education, and communication interventions can influence compliance with MMS consumption among pregnant women (Islami & Maulina, 2026). Maternal acceptance is similarly relevant because perceptions regarding the benefits and tolerability of MMS can affect willingness to continue supplementation during pregnancy (Kissell et al., 2025). The present study did not measure previous adherence as an independent determinant of baseline anemia, so the observed prevalence cannot be attributed directly to supplementation behavior. The baseline measurement instead establishes the hematological condition against which the response following MMS administration can be assessed. This methodological distinction is important because the one-group pretest–posttest design evaluates change within the same participants but does not independently isolate every determinant of the initial anemia.

The baseline condition further supports the relevance of MMS as an intervention that addresses maternal micronutrient requirements through a broader nutritional formulation. UNIMMAP-based MMS contains iron, folic acid, and additional vitamins and minerals involved in hematopoiesis, cellular metabolism, and nutrient utilization, providing a more comprehensive micronutrient profile than supplementation focused only on iron and folic acid (United Nations International Multiple Micronutrient Preparation, 2023). Evidence from a systematic review has indicated that MMS may offer health and economic advantages compared with iron–folic acid supplementation, although the magnitude of benefit can vary according to intervention characteristics and population context (Alfiani et al., 2025). The presence of 17 anemic participants before intervention creates an appropriate empirical basis for examining whether MMS is associated with movement from anemic to non-anemic status. At the same time, the 21 participants who were not anemic at baseline provide information about whether the intervention is accompanied by a favorable shift in overall hemoglobin status rather than only recovery among participants initially classified as anemic. This distinction becomes particularly relevant when interpreting the post-intervention findings because an increase in mean hemoglobin does not necessarily indicate that every participant achieves a non-anemic classification. Assessment of both continuous Hb changes and categorical anemia transitions therefore provides a more informative evaluation of the intervention's hematological effect.

From an analytical perspective, the baseline distribution demonstrates the value of combining continuous and categorical indicators in evaluating MMS effectiveness. Mean hemoglobin concentration can quantify the magnitude of hematological change, whereas anemia status provides a clinically interpretable indication of whether participants cross the relevant diagnostic threshold. Previous evidence has shown that MMS can influence maternal hemoglobin and anemia outcomes, although the magnitude of these effects may differ according to iron dose, baseline nutritional conditions, adherence, and study design (Gomes et al., 2022). The baseline anemia prevalence of 44.7%

indicates that the study population contained sufficient variation in hematological status to examine changes following supplementation. However, because the study did not include a comparison group, subsequent improvement cannot be interpreted as definitive evidence that MMS alone caused every observed change. Gestational progression, dietary intake, adherence to supplementation, antenatal counseling, and other concurrent health interventions may also have contributed to changes in hemoglobin during the observation period. The baseline findings therefore serve as the critical comparator for the subsequent within-participant analysis and provide the empirical foundation for determining whether MMS administration was associated with improved hemoglobin levels and reduced anemia at the Siwalan Community Health Center.

Hemoglobin Levels After MMS Intervention

Following 30 days of MMS administration, the hemoglobin profile of the pregnant women showed a clear improvement compared with the baseline condition. The mean hemoglobin concentration increased from 11.345 ± 1.134 g/dL before intervention to 12.268 ± 1.182 g/dL after intervention, representing an absolute mean increase of 0.923 g/dL. This shift indicates that the hematological status of the participants improved during the intervention period, although individual responses may have varied. The increase is clinically relevant because hemoglobin concentration reflects the capacity of maternal blood to transport oxygen to maternal tissues and the developing fetus. The post-intervention findings also need to be interpreted alongside the categorical anemia distribution because improvement in mean hemoglobin does not necessarily mean that every participant moved above the anemia threshold. The combination of continuous and categorical outcomes provides a more comprehensive representation of the observed hematological changes.

The categorical distribution similarly demonstrated a substantial reduction in anemia after MMS administration. The number of participants classified as anemic decreased from 17 women (44.7%) at baseline to 6 women (15.8%) after the intervention, while the number classified as not anemic increased from 21 women (55.3%) to 32 women (84.2%). This pattern indicates that the improvement was not limited to a modest increase in average hemoglobin but was also reflected in a clinically meaningful redistribution of anemia status. The reduction in anemia prevalence is particularly relevant because maternal anemia remains an important nutritional and obstetric concern requiring effective interventions within routine antenatal services. The findings suggest that the MMS program implemented at Siwalan Community Health Center was accompanied by an improvement in maternal hematological status during the observed period. The post-intervention distribution is presented in Table 3 to illustrate the magnitude of the change in anemia classification.

Table 3. Hemoglobin Level After MMS Intervention at Siwalan Community Health Center, Pekalongan Regency in May 2026 (n=38)

Hemoglobin Level	Frequency (f)	Percentage (%)
Anemia	6	15.8
Not Anemic	32	84.2
Total	**38**	**100.0**

The findings presented in Table 3 indicate that 84.2% of participants were classified as not anemic following MMS administration, compared with 55.3% before the intervention. The increase in the non-anemic group corresponds to the movement of 11 participants from the anemic category into the non-anemic category, while six participants remained anemic after supplementation. This pattern suggests that MMS was associated with a favorable hematological response among a substantial proportion of participants, although the persistence of anemia in some women indicates that supplementation alone may not completely resolve maternal anemia within a short intervention period. A similar positive pattern has been reported in Indonesian studies evaluating MMS among pregnant women, where supplementation was associated with increased hemoglobin concentrations and improved anemia status (Subair, 2023). Evidence from a case study involving MMS distribution and nutrition education also indicates that implementation of supplementation within primary healthcare services can support maternal nutritional improvement (Dewiyanti Fitria et al., 2025). The persistence

of six anemia cases in the present study reinforces the need to recognize maternal anemia as a multifactorial condition rather than an outcome determined solely by micronutrient supplementation.

The observed increase in hemoglobin can be explained through the complementary biological functions of the micronutrients contained in MMS. Iron provides the central substrate for hemoglobin synthesis, whereas folate and vitamin B12 participate in DNA synthesis and erythrocyte maturation, while vitamin C can support iron absorption and utilization. Other micronutrients included in MMS contribute to enzymatic and metabolic processes that support normal hematopoietic function. A comprehensive review of MMS during pregnancy has emphasized that multiple micronutrients may provide clinical benefits beyond the effects attributable to a single nutrient, although outcomes depend on maternal nutritional status and the characteristics of supplementation (Liu et al., 2025). The biological rationale is particularly relevant in populations where maternal dietary intake may not consistently provide adequate amounts of several micronutrients simultaneously. The present findings are therefore compatible with the conceptual framework that correction of multiple nutritional insufficiencies can support more effective erythropoiesis than addressing a single nutrient deficiency in isolation.

The magnitude of the hemoglobin increase in this study is also consistent with evidence from previous intervention-based research, although direct comparison should account for differences in populations, intervention duration, and study designs. Meiyanti (2024) reported an increase in hemoglobin among pregnant women receiving MMS, supporting the potential hematological benefit observed in the present study. Similar evidence has been reported in a quasi-experimental study in which MMS administration was associated with changes in anemia status among pregnant women (Katili, 2025). Research examining MMS in relation to anemia has also reported favorable associations between supplementation and maternal hematological outcomes, strengthening the plausibility of the improvement observed at Siwalan Community Health Center (Lestari & Heryani, 2025). Nevertheless, the magnitude of response should not be assumed to be uniform across settings because iron dose, adherence, dietary intake, gestational age, and baseline anemia severity can modify the hematological response. Recent research has specifically highlighted the importance of iron dose in determining the potential effectiveness of MMS for maternal anemia prevention, indicating that formulation characteristics remain an important consideration when interpreting intervention outcomes (Smith et al., 2025). The increase observed in the present study therefore provides local empirical evidence of a favorable response while remaining subject to contextual factors affecting supplementation effectiveness.

The reduction in anemia also needs to be considered in relation to participant acceptance and adherence to MMS consumption. A supplement can only exert its intended biological effect when it is consumed consistently, making adherence an important pathway connecting program availability with clinical outcomes. Research among Indonesian pregnant women has identified knowledge, attitudes, and acceptance as relevant dimensions of maternal perspectives toward MMS, suggesting that implementation success depends partly on how women perceive and engage with supplementation (Alfaqeeh et al., 2025). Studies examining education, family support, and knowledge similarly indicate that behavioral and social factors may influence compliance with MMS consumption during pregnancy (Yuriani & Maulina, 2025). The present study did not establish a causal pathway between acceptance, adherence, and hemoglobin improvement because these behavioral variables were not analyzed as independent predictors. The favorable post-intervention findings may nevertheless reflect the combined influence of MMS provision through antenatal care and participants' ability to follow the supplementation regimen during the intervention period. Future implementation research should examine adherence quantitatively because differences in consumption patterns could help explain why six participants remained anemic despite the overall improvement in hemoglobin status.

Effectiveness of MMS in Increasing Hemoglobin Levels and Reducing Anemia

The effectiveness of MMS was evaluated by examining changes in hemoglobin concentration and anemia status among the same 38 pregnant women before and after the 30-day intervention. Because the sample consisted of fewer than 50 participants, the Shapiro–Wilk test was applied to assess the distributional characteristics of the hemoglobin measurements. The pre-intervention hemoglobin measurement produced a significance value of 0.056, whereas the post-intervention measurement produced a significance value of 0.356. Both values exceeded the 0.05 threshold, indicating that the

distributions did not show statistically significant departures from normality. The normality assessment provided the basis for applying the paired t-test to compare mean hemoglobin concentrations before and after MMS administration. The subsequent analysis was complemented by the McNemar test to examine changes in paired categorical anemia status.

The descriptive findings showed an increase in mean hemoglobin from 11.345 ± 1.1342 g/dL before MMS administration to 12.268 ± 1.1823 g/dL after the intervention. The mean difference was approximately 0.924 g/dL, with a 95% confidence interval of 0.744–1.103 g/dL, indicating a consistently positive direction of change. This improvement was accompanied by a reduction in the proportion of participants classified as anemic. The combination of continuous and categorical outcomes provides a more comprehensive assessment because changes in average hemoglobin do not necessarily correspond directly to changes across the clinical anemia threshold. The statistical findings are presented sequentially in Tables 4–7 to distinguish the assumptions, comparative test, categorical transition, and integrated interpretation of the intervention response. This analytical structure also permits the observed changes to be considered in relation to the biological and behavioral mechanisms underlying maternal micronutrient supplementation.

Table 4. Normality Test of Hemoglobin Levels Before and After MMS Intervention at Siwalan Community Health Center, Pekalongan Regency (n=38)

Variable	Shapiro–Wilk Statistic	df	Sig.
Before MMS	0.944	38	0.056
After MMS	0.969	38	0.356

Table 4 demonstrates that the Shapiro–Wilk significance values for hemoglobin before and after MMS administration were 0.056 and 0.356, respectively. Both values were greater than 0.05, indicating that the hemoglobin measurements met the distributional criterion used for the subsequent parametric analysis. The finding supports the use of the paired t-test for comparing the two related hemoglobin measurements. This procedure is appropriate because the study measured hemoglobin repeatedly in the same participants rather than comparing independent groups. The normality assessment therefore strengthens the statistical validity of the subsequent analysis, although the more specific assumption for a paired t-test concerns the distribution of the paired differences rather than the two measurements independently. The statistical comparison of the pre-intervention and post-intervention means is presented in Table 5.

Table 5. Paired t-Test Results of Hemoglobin Levels Before and After MMS Intervention at Siwalan Community Health Center, Pekalongan Regency (n=38)

Variable	Mean (g/dL)	Standard Deviation	Standard Error Mean	p-value
Before MMS	11.345	1.1342	0.1840	<0.001
After MMS	12.268	1.1823	0.1918	<0.001

Table 5 shows that mean hemoglobin increased by 0.923–0.924 g/dL following MMS administration, while the paired t-test yielded $t(37) = 10.429$ with $p < 0.001$. The 95% confidence interval for the mean difference of 0.744–1.103 g/dL indicates that the estimated improvement remained positive across the interval. The statistical evidence therefore demonstrates a significant difference in hemoglobin concentration between the two measurement periods. Similar findings have been reported in studies evaluating MMS among pregnant women, supporting the potential effectiveness of multiple micronutrient supplementation in improving maternal hemoglobin status (Meiyanti, 2024). Evidence from a quasi-experimental study also indicates that MMS administration can produce favorable changes in maternal anemia status (Katili, 2025). The magnitude of the observed improvement is clinically relevant because an increase approaching 1 g/dL may enable women with borderline hemoglobin concentrations to move above the anemia threshold.

The observed increase in hemoglobin has a plausible biological basis because MMS provides several nutrients involved in erythropoiesis and hemoglobin synthesis. Iron directly contributes to

hemoglobin formation, while folate and vitamin B12 are involved in DNA synthesis and erythrocyte maturation, and vitamin C supports iron absorption and utilization. A multiple-micronutrient formulation can therefore address several nutritional pathways simultaneously rather than focusing exclusively on iron replacement. UNIMMAP-based MMS is designed to provide a combination of vitamins and minerals required to support maternal nutritional needs during pregnancy (United Nations International Multiple Micronutrient Preparation, 2023). Evidence from a broader review also indicates that MMS may provide clinical benefits during pregnancy through complementary effects of multiple micronutrients, although the magnitude of benefit can vary according to maternal nutritional conditions and formulation characteristics (Liu et al., 2025). The continuous increase in hemoglobin observed in this study is therefore consistent with the proposed biological role of multiple micronutrient supplementation in supporting maternal hematological adaptation.

Table 6. McNemar Test of Anemia Status Before and After MMS Intervention at Siwalan Community Health Center, Pekalongan Regency (n=38)

Initial Anemia Status	Anemia After MMS	Not Anemic After MMS	Total	Exact p-value	Approximate McNemar χ^2
Anemia	6	11	17	0.00098	9.09
Not Anemic	0	21	21	—	—

Table 6 shows that 11 of the 17 participants who were anemic before the intervention changed to the non-anemic category after MMS administration, equivalent to 64.7% of the baseline anemia group. Six participants remained anemic, while none of the 21 participants who were initially non-anemic became anemic after the intervention. The exact McNemar p-value of approximately 0.001 indicates a statistically significant change in paired anemia status. The prevalence of anemia consequently decreased from 44.7% before intervention to 15.8% after intervention, representing a reduction of 28.9 percentage points. This finding is consistent with cohort evidence showing that multiple micronutrient supplementation may reduce the risk of anemia during pregnancy (Zhong et al., 2025). The categorical improvement also complements the paired t-test result, indicating that the increase in average hemoglobin was accompanied by movement across the clinically relevant anemia classification.

The transition from anemia to non-anemia may reflect the combined nutritional effects of MMS and the delivery of supplementation through routine antenatal care. Previous research has demonstrated that MMS can improve maternal anemia outcomes, although the magnitude of benefit varies according to iron dose and other characteristics of the intervention (Gomes et al., 2022). The present findings are also compatible with Indonesian evidence reporting favorable anemia-related outcomes following MMS implementation among pregnant women (Lestari & Heryani, 2025). The persistence of six anemia cases indicates that the response was not uniform and that factors beyond supplementation may influence hematological recovery. Maternal dietary intake, baseline nutritional reserves, gestational age, adherence, infection, and other health conditions may contribute to residual anemia. The absence of any transition from non-anemia to anemia is nevertheless notable because it indicates that the intervention period was characterized by an overall favorable direction of categorical change.

Table 7. Integrated Hematological Changes Following MMS Administration at Siwalan Community Health Center, Pekalongan Regency (n=38)

Indicator	Before MMS	After MMS	Change	Interpretation
Mean hemoglobin	11.345 g/dL	12.268 g/dL	+0.924 g/dL	Improved
Anemia status	17 (44.7%)	6 (15.8%)	−11 cases	Reduced
Not anemic	21 (55.3%)	32 (84.2%)	+11 cases	Increased
Participants changing from anemia to non-anemia	—	11 (64.7% of baseline anemia cases)	+11	Favorable transition

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Paired t-test	—	$t(37)=10.429$; $p<0.001$	Significant	Significant Hb improvement
McNemar test	—	$\chi^2=9.09$; exact $p\approx0.001$	Significant	Significant anemia-status change

Table 7 synthesizes the principal hematological findings and demonstrates convergence between the continuous and categorical indicators of intervention response. Mean hemoglobin increased by 0.924 g/dL, while the number of anemic participants decreased by 11 cases and the non-anemic group increased by the same number. The paired t-test and McNemar test both produced statistically significant findings, providing complementary evidence of improvement in hematological status. This pattern is important because the intervention effect was observable not only as a shift in the group mean but also as a clinically interpretable transition from anemia to non-anemia. The findings are compatible with evidence indicating that MMS can improve maternal anemia outcomes and may offer advantages over conventional iron–folic acid supplementation under appropriate conditions (Alfiani et al., 2025). The integrated result therefore supports the potential value of MMS as part of maternal anemia management at the primary healthcare level.

The favorable response should nevertheless be interpreted within the behavioral and implementation context of maternal supplementation. Consistent consumption is necessary for the micronutrients contained in MMS to produce their intended biological effects, while knowledge, acceptance, and family support can influence adherence. Research in Indonesia has identified maternal acceptance as an important factor in the implementation of MMS during pregnancy (Alfaqeeh et al., 2025). Evidence concerning education and communication has also demonstrated the relevance of information interventions for improving compliance with MMS consumption (Islami & Maulina, 2026). The current study did not model adherence, knowledge, or family support as independent determinants of hemoglobin change, preventing direct attribution of individual responses to these factors. The persistence of anemia among six participants reinforces the multifactorial nature of maternal anemia and indicates that MMS should be accompanied by dietary counseling, adherence monitoring, and appropriate clinical assessment. These considerations are particularly important for translating the favorable statistical findings into sustainable improvements in maternal health services.

CONCLUSION

This study demonstrates a meaningful change in anemia status among pregnant women following 30 days of Multiple Micronutrient Supplementation (MMS) at Siwalan Community Health Center, Pekalongan Regency, in 2026. The proportion of pregnant women classified as anemic decreased from 17 respondents (44.7%) before intervention to 6 respondents (15.8%) after intervention. Mean hemoglobin concentration also increased from 11.345 ± 1.134 g/dL at baseline to 12.268 ± 1.182 g/dL following MMS administration, representing a mean increase of 0.924 g/dL. The paired t-test demonstrated a statistically significant difference in hemoglobin concentration before and after the intervention ($p < 0.001$), while the McNemar test indicated a significant change in anemia status ($p = 0.001$). These findings indicate that MMS administration was associated with improved hematological status and a lower proportion of anemia among pregnant women receiving routine antenatal care at the study site. The findings provide empirical evidence supporting the implementation of MMS as part of maternal nutritional services at the primary healthcare level. Nevertheless, the one-group pretest–posttest design without a comparison group limits causal interpretation, as changes in dietary intake, pregnancy stage, adherence, concurrent healthcare interventions, or other unmeasured factors may have contributed to the observed improvements.

The findings have practical implications for strengthening anemia prevention within antenatal care through continued MMS provision accompanied by systematic monitoring of consumption and hemoglobin status. Healthcare providers should integrate supplementation with individualized nutrition education and regular assessment of adherence to address behavioral and nutritional factors that may influence the effectiveness of MMS. Documentation through maternal health records can also support continuity of monitoring and facilitate early identification of pregnant women who remain anemic after supplementation. For educational institutions, the findings may serve as an empirical reference for teaching maternal health, pregnancy nutrition, anemia prevention, and evidence-based midwifery practice. Future research should employ stronger designs, particularly quasi-experimental studies with

comparison groups or randomized controlled trials, to establish a more robust causal relationship between MMS administration and hematological outcomes. Subsequent studies should also consider potential confounding variables such as dietary iron intake, gestational age, baseline nutritional status, adherence, and previous supplementation exposure. Such research would strengthen the methodological evidence required to evaluate the effectiveness, implementation, and broader applicability of MMS programs for anemia prevention among pregnant women.

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