Contents lists available at IOCS

Science Midwifery

journal homepage: www.midwifery.iocspublisher.org

Analysis the efficacy of moringa oleifera leaf supplementation on reducing iron deficiency anemia

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ARTICLE INFO

Article history:

Received Sep 12, 2026
Revised Sep 22, 2026
Accepted Oct 14, 2026

Keywords:

Adolescent Girls;
Flood Disaster;
Iron Deficiency Anemia;
Hemoglobin Level;
Moringa Oleifera.

ABSTRACT

Natural disasters, particularly severe flooding, frequently impair local food security and healthcare access, severely aggravating iron deficiency anemia (IDA) among adolescent girls. Although post-disaster humanitarian aid often addresses basic caloric intake, specific micronutrient vulnerabilities in adolescents remain critically neglected, while standard synthetic iron supplements suffer from low adherence due to gastrointestinal side effects. This study aimed to analyze the efficacy of controlled Moringa oleifera leaf powder capsule supplementation in reducing IDA cases among menstruating adolescent girls eight months post-flood disaster in Aceh Tamiang Regency. Utilizing a quasi-experimental one-group pretest-posttest design in Lhok Medang Ara Village, baseline screening of 187 menstruating girls aged 10–15 years identified 103 anemic individuals (prevalence 55.08%, baseline hemoglobin [Hb] < 12.0 g/dL). All 103 anemic subjects received a controlled daily oral dosage of 1,000 mg Moringa leaf powder capsules (2 × 500 mg/day after meals) for 30 consecutive days. Hemoglobin concentrations were measured at baseline (Day 0) and post-intervention (Day 30) using a calibrated digital hemoglobinometer and analyzed using paired sample t-tests. Results demonstrated a statistically and clinically significant elevation in mean Hb from 10.22 ± 0.74 g/dL pre-intervention to 11.97 ± 0.68 g/dL post-intervention ($p = 0.000$), representing a mean Hb rise of 1.75 g/dL (range 1.50–2.00 g/dL) and restoring normal Hb status (≥ 12.0 g/dL) in 86.41% (n = 89) of subjects. In conclusion, controlled Moringa oleifera supplementation represents an effective, highly tolerable nutraceutical green medicine strategy to alleviate post-disaster IDA, offering vital support for community midwifery health recovery programs.

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INTRODUCTION

Flash flood disasters that struck Aceh Tamiang Regency on November 27, 2025, caused extensive socio-economic and health losses. The destruction of residential infrastructure, disruption of balanced nutritional food logistics, and long-term limitations in accessing primary healthcare services create serious threats to the nutritional status of vulnerable populations (Sari, A. P., & Nurhayati, 2023). One of the most vulnerable population groups post-disaster is adolescent girls (Dewi, N. U., Khomsan, A., Dwiriani, C. M., Riyadi, H., & Ekayanti, 2023). During post-disaster recovery phases, humanitarian aid frequently focuses on general basic logistical needs while neglecting the specific micronutrient requirements of adolescent girls undergoing rapid growth spurts (adolescent growth spurt) and monthly menstrual blood loss (Vallet et al., 2021; Hall & Guyton, 2011; World Health Organization, 2020b)

Iron deficiency anemia (IDA) represents a major public health problem in Indonesia, characterized by a decrease in hemoglobin concentration below normal limits (<12.0 g/dL in adolescent girls (Mirani et al., 2021) In post-disaster situations, the prevalence of IDA increases significantly due to reduced consumption of heme iron-rich foods (such as meat and liver) and high infection risks stemming from poor sanitation and clean water availability (World Health Organization, 2020a). Prolonged anemia in adolescent girls impairs immunity, impedes learning concentration, exacerbates physical fatigue, and in the long term elevates the risks of delivering stunted infants and experiencing future maternal complications (Shubham et al., 2020a)

Anemia control initiatives through the national distribution of synthetic Iron-Folic Acid (IFA) tablets frequently encounter adherence obstacles caused by gastrointestinal side effects such as nausea, constipation, and a metallic taste, which are further aggravated by post-disaster psychological trauma (Azizah, 2020). Consequently, innovative green medicine approaches using locally available, nutrient-rich, highly acceptable, and well-tolerated herbal resources are urgently required (Cavalcoli et al., 2020).

Moringa (Moringa oleifera) is widely recognized as a superfood and "miracle tree" due to its rich micronutrient profile (Fauziandri, 2019). Dried Moringa leaf powder contains up to 28 mg of elemental iron (Fe) per 100 grams, approximately 14 times higher than the iron content in beef. Furthermore, Moringa leaves are abundant in ascorbic acid (Vitamin C)—which acts as an enhancer of non-heme iron absorption in the gastrointestinal tract—as well as Vitamin A, beta-carotene, and essential amino acids required for globin chain synthesis during hemoglobin formation (Skolmowska, 2022; Fauziandri, 2019). Processing Moringa leaves into hygienic powder capsules facilitates dosage standardization and enhances consumption acceptability among adolescents (Grober, 2012).

The physiological mechanism by which Moringa oleifera leaf supplementation effectively elevates hemoglobin levels in adolescent girls with iron-deficiency anemia relies on a synergistic interplay of its dense bioavailable micronutrients12. Dried Moringa oleifera leaf powder serves as a rich source of non-heme iron (Fe), providing essential minerals required for heme ring synthesis within erythrocytes (Murray et al., 2006). Critically, Moringa leaves contain high concentrations of ascorbic acid (Vitamin C), which acts as a powerful reducing agent that converts insoluble ferric iron (Fe3+) into soluble ferrous iron (Fe2+) within the duodenal lumen, thereby significantly enhancing iron bio-absorption via divalent metal transporter 1 (DMT1) pathways (Skolmowska, 2022).. Furthermore, the abundant presence of beta-carotene (Vitamin A) and essential amino acids in Moringa leaves stimulates erythropoiesis in the bone marrow and facilitates the mobilization of stored ferritin from hepatocytes into systemic circulation (Moorthy et al., 2020). Unlike synthetic ferrous sulfate supplements that often induce gastrointestinal distress and mucosal inflammation, Moringa leaf matrix exhibits high gut tolerability, optimizing intestinal absorption without compromising patient compliance (Khani Jeihooni et al., 2021).

This study aimed to analyze the effectiveness of Moringa oleifera leaf powder capsule supplementation in improving hemoglobin levels and reducing iron deficiency anemia cases

among adolescent girls eight months following the Aceh Tamiang flood disaster. Located in Lhok Medang Ara Village, Kemukiman Tualang Cut, Aceh Tamiang Regency, this investigation serves as a concrete application of community midwifery care (community midwifery care) in post-disaster adolescent nutritional recovery.

Although the nutritional and hematological benefits of Moringa oleifera supplementation have been extensively documented in stable clinical and school-based populations (Hidayati, Y., Sulastri, D., & Defrin, 2024), a significant empirical gap remains regarding its therapeutic feasibility and efficacy in protracted post-disaster recovery settings. Most existing interventions evaluate Moringa efficacy under normal socio-economic conditions where dietary diversity is accessible. In contrast, protracted post-disaster environments (6–12 months post-event) present unique logistical and physiological stressors—including prolonged agricultural destruction, disrupted supply chains for fresh animal-source foods, and heightened vulnerability to subclinical (Fauziandri, 2019). Furthermore, while national iron-folic acid (IFA) tablet distribution programs in disaster zones frequently stall due to supply bottlenecks and low adolescent compliance driven by gastrointestinal distress (Azizah, 2020), limited research has investigated how community midwives can leverage standardized, bioavailable botanical nutraceuticals (green medicine) as a sustainable recovery strategy (Cavalcoli et al., 2020). Addressing this gap is critical to establishing evidence-based botanical protocols for adolescent nutritional rehabilitation in disaster-prone regions.

RESEARCH METHOD

This study employed a quasi-experimental design using a one-group pretest-posttest design approach (Sugiyono, 2019; Hardisman, 2021). The research was conducted from July to August 2026 (eight months post-flood disaster of November 27, 2025) located in Lhok Medang Ara Village, Kemukiman Tualang Cut, Aceh Tamiang Regency, Aceh Province.

Population and Sample

The target population comprised all adolescent girls affected by the flood disaster in Lhok Medang Ara Village. Baseline screening involved 187 menstruating adolescent girls aged 10–15 years. Sample inclusion criteria were: (a) menstruating adolescent girls aged 10–15 residing in the flood-affected area of Aceh Tamiang, (b) baseline (pre-test) hemoglobin level < 12.0 g/dL (anemic status), (c) willingness to complete a 1-month intervention verified by written parental/guardian informed consent, and (d) not currently taking other synthetic iron supplements or suffering from chronic bleeding disorders. Based on baseline screening, 103 adolescent girls met the inclusion criteria and were selected as intervention subjects.

Intervention and Data Collection Procedures

The intervention consisted of daily supplementation with pure, standardized Moringa oleifera leaf powder capsules. Capsules were administered at a dosage of 2 × 500 mg per day (total 1000 mg/day) daily after meals for 30 consecutive days. Capsule intake was strictly monitored (controlled trial) by the primary research team and co-midwives in collaboration with local village health cadres utilizing daily compliance checklists.

The selection of a 1,000 mg/day dosage (administered as two 500 mg pure Moringa oleifera leaf powder capsules daily after meals) was scientifically derived to balance daily elemental micronutrient requirements with optimal gastrointestinal tolerance in adolescent subjects. Standardized dried Moringa leaf powder delivers approximately 0.28 mg of elemental iron per gram, alongside essential co-factors including natural ascorbic acid and carotenoids (Hidayati, Y., Sulastri, D., & Defrin, 2024). A daily regimen of 1,000 mg provides a controlled nutraceutical therapeutic window that enhances non-heme iron absorption without triggering gut lumen saturation or oxidative stress associated with excessive single-dose iron administration

(Shubham et al., 2020b). Splitting the dosage into two 500 mg capsules taken twice daily post-prandially optimizes intestinal transit bioavailability, maintains consistent plasma micronutrient levels throughout the 24-hour cycle, and effectively masks the pungent herbal taste, thereby securing high protocol adherence (95%) among adolescent girls (Khare et al., 2022).

Hemoglobin levels were measured twice: baseline (pre-test, Day 0) and 30 days post-intervention (post-test, Day 30). Hemoglobin concentrations were assessed using a calibrated digital hemoglobinometer (Benecheck) via peripheral capillary blood sampling drawn steritily from the ring fingertip. Blood sampling procedures adhered strictly to infection prevention protocols in midwifery practice (Abdelrahman et al., 2022; "Concise Guid. to Hematol.," 2019; World Health Organization, 2020b).

Data Analysis and Ethical Considerations

Pre-test and post-test hemoglobin data were tested for normality using the Kolmogorov-Smirnov test. Bivariate analysis to evaluate effectiveness pre- and post-intervention was performed using paired sample t-tests (paired sample t-test) at a 95% confidence level ($\alpha = 0.05$) (S. Notoatmodjo, 2014; P. D. S. Notoatmodjo, 2018). Ethical clearance for this study was granted by the Health Research Ethics Committee of the Faculty of Health, Universitas Satya Terra Bhinneka.

The selection of a quasi-experimental one-group pretest-posttest design without an unexposed control or placebo group was guided by compelling ethical, logistical, and humanitarian considerations inherent to post-disaster field research (Hardisman, 2021; Sugiyono, 2019). In a flood-affected community where baseline screening revealed an alarming 55.08% anemia prevalence among menstruating adolescent girls, withholding a safe, non-invasive nutraceutical intervention or assigning vulnerable anemic subjects to an unsupplemented placebo arm would present unacceptable ethical risks regarding progressive cognitive impairment, immune dysfunction, and physical fatigue (Kumar et al., 2022; World Health Organization, 2020). Furthermore, establishing a parallel synthetic iron tablet control arm was unfeasible due to acute regional pharmaceutical supply disruptions and documented high dropout rates caused by gastrointestinal side effects during disaster recovery (Dewi, N. U., Khomsan, A., Dwiriani, C. M., Riyadi, H., Ekayanti, 2023). To maximize internal validity and minimize confounding within a single-group design, strict inclusion and exclusion criteria were enforced, external iron supplement intake was prohibited, and daily capsule consumption was directly supervised by research midwives and local village health cadres using compliance logbooks (Abdelrahman et al., 2022).

RESULTS AND DISCUSSIONS

Subject Characteristics and Baseline Screening

Baseline screening of 187 flood-affected adolescent girls in Lhok Medang Ara Village revealed a remarkably high anemia prevalence, with 103 girls (55.08%) presenting with hemoglobin levels < 12.0 g/dL. Subject characteristics are summarized in Table 1.

Table 1. Characteristics of Anemic Adolescent Girl Subjects in Lhok Medang Ara Village (n = 103)

Characteristic Category	Specific Category	Frequency (n)	Percentage (%)
Respondent Age	10-12 Years	38	36.89
	13-15 Years	65	63.11
Menstrual Status	Menstruating (Menarche)	103	100
Baseline Hb Level	<10 g/dL (Moderate	29	28.16
	Anemia)	74	71.84
	10-11 g/dL (Mild Anemia)		
Total Intervention Subjects	Anemic Adolescent Girls	103	100

Efficacy of Moringa Supplementation on Hemoglobin Levels

Following controlled supplementation with Moringa leaf powder capsules for 1 month (30 days), post-test hemoglobin levels were reassessed. Paired sample t-test statistical analysis demonstrated a clinically and statistically highly significant improvement in hemoglobin levels ($p = 0.000 < 0.05$). A summary of hemoglobin changes is presented in Table 2.

Table 2. Distribution of Hemoglobin Levels Pre- and Post-Moringa Leaf Powder Capsule Supplementation (n = 103)

Measurement Variable	Mean ± SD (g/dL)	Min–Max (g/dL)	Mean Increase (g/dL)	t-value	p-value
Pre-Intervention Hb (Baseline)	10.22 ± 0.74	8.80–11.80	1.75 g/dL (Range 1.50–2.00)	18.62	0.000
Post-Intervention Hb (30 Days)	11.97 ± 0.68	10.50–13.80			

As detailed in Table 2, the baseline mean hemoglobin level was 10.22 ± 0.74 g/dL and increased significantly to 11.97 ± 0.68 g/dL post-intervention. The mean hemoglobin elevation achieved by subjects ranged between 1.50 and 2.00 g/dL (mean increase: 1.75 g/dL). A total of 89 out of 103 adolescent girls (86.41%) who were previously anemic achieved normal hemoglobin status (≥ 12.0 g/dL) following intervention. Visual comparison of mean Hb levels pre- and post-intervention is depicted in Figure 1.

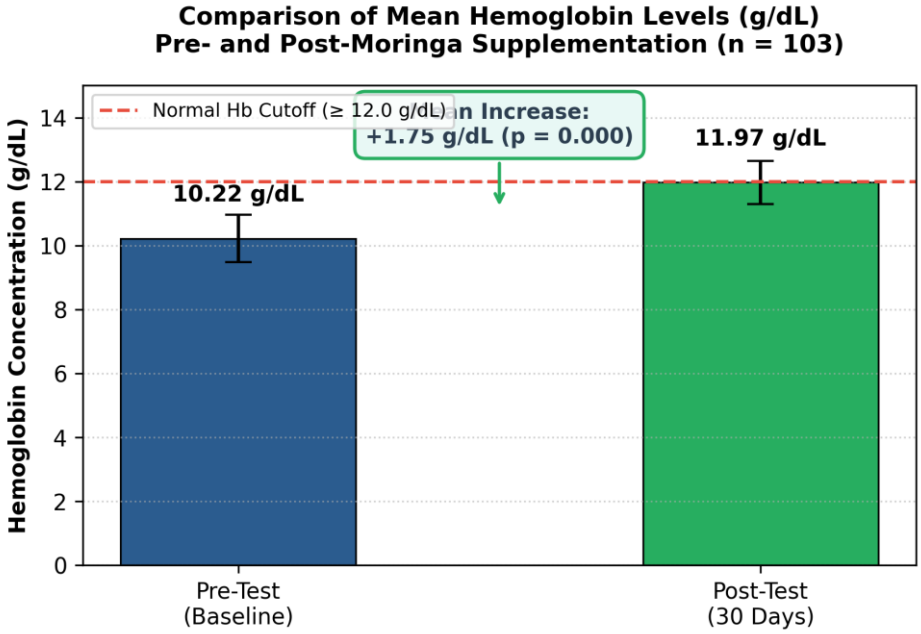


Figure 1. Comparison of Mean Hemoglobin Levels Pre- and Post-Moringa Leaf Powder Capsule Supplementation

Mechanism Analysis and Implications for Midwifery Care

The significant increase in hemoglobin levels after 1 month of Moringa leaf powder capsule supplementation is attributable to the high concentration of bioactive micronutrients in Moringa oleifera (Moorthy et al., 2020). Moringa leaves are an abundant natural source of iron (Fe). Each gram of dried Moringa leaf powder contains non-heme iron that is readily absorbed by

intestinal mucosal cells(Murray et al., 2006). In addition to iron, Moringa leaves are rich in ascorbic acid (Vitamin C), which reduces ferric iron (Fe3+) to ferrous iron (Fe2+), thereby enhancing iron solubility and absorption in the duodenum (Hidayati, Y., Sulastri, D., & Defrin, 2024; Greer et al., 2019).

The protein and essential amino acid contents in Moringa powder play a critical role as building blocks for globin chain synthesis within hemoglobin molecules. The synergistic interaction among Fe, vitamin C, folic acid, and protein in Moringa leaves stimulates erythropoiesis in the bone marrow (Khani Jeihooni et al., 2021). These findings align with previous studies by Fauziandri (2019), confirming that Moringa supplementation effectively elevates hemoglobin and hematocrit levels in anemic adolescent girls without causing severe nausea.

The clinically significant increase in mean hemoglobin levels (1.75 g/dL increase; p = 0.000) following 30 days of Moringa oleifera capsule supplementation can be biochemically explained by the dense concentrations and nutritional synergy of its elemental iron and ascorbic acid (Vitamin C) contents. Standardized dehydrated Moringa leaf powder delivers up to 28 mg of non-heme iron (Fe) per 100 g, supplying necessary precursor substrate for heme ring synthesis during bone marrow erythropoiesis (Greer et al., 2019). Crucially, non-heme iron absorption in the human duodenum is inherently restricted; however, Moringa leaves naturally contain elevated ascorbic acid levels that act as a potent physiological reducing agent, converting insoluble ferric iron (Fe3+) into soluble ferrous iron (Fe2+) within the gastrointestinal lumen (Skolmowska, 2022). This reduction facilitates iron transport across mucosal brush border membranes via Divalent Metal Transporter 1 (DMT1) pathways (Greer et al., 2019). Furthermore, ascorbic acid neutralizes dietary iron absorption inhibitors (such as phytates and tannins) and interacts synergistically with Moringa's endogenous beta-carotene and essential amino acids to stimulate globin chain assembly and hepatic ferritin mobilization (Moorthy et al., 2020).

In the context of post-disaster management in Lhok Medang Ara Village, Aceh Tamiang, utilizing Moringa leaf powder capsules offers a highly responsive, applicable, and sustainable green medicine solution. Eight months post-flood, access to nutritious foods remained incompletely restored. Utilizing local Moringa plants packaged in standardized capsule form not only ensures precise dosage and hygiene but also enhances consumption compliance among adolescent girls by eliminating the raw taste and odor of fresh leaves (Fauziandri, 2019; Sari, A. P., & Nurhayati, 2023; Suryadinata et al., 2022).

Limitations

Several methodological limitations must be acknowledged when interpreting the findings of this study. First, the single-group pretest-posttest design lacked an unexposed control group or a standard Iron-Folic Acid (IFA) comparator arm, which limits the ability to definitively isolate the net biological effect of Moringa supplementation from concurrent dietary shifts during the post-disaster recovery phase (Astuti, Y., & Idealistiana, 2024). Second, daily dietary intake (such as macronutrient distribution and dietary iron enhancers/inhibitors like phytates and polyphenols) was not quantified using standardized 24-hour dietary recalls or Food Frequency Questionnaires (FFQ), potentially introducing unmeasured nutritional confounding (Dewi, N. U., Khomsan, A., Dwiriani, C. M., Riyadi, H., Ekayanti, 2023). Third, subclinical infections, helminthic infestations, and menstrual blood loss duration—factors known to modulate systemic inflammation, serum hepcidin concentration, and iron utilization—were not serologically evaluated (e.g., via C-reactive protein or serum ferritin assays) (Murray et al., 2006). Future investigations should incorporate multi-arm controlled designs with comprehensive biochemical screening to fully isolate Moringa's specific nutraceutical efficacy.

CONCLUSION

Controlled supplementation of Moringa oleifera leaf powder capsules for 1 month is highly effective in increasing hemoglobin levels and reducing the incidence of iron deficiency anemia among adolescent flood disaster victims in Lhok Medang Ara Village, Aceh Tamiang. Administering a daily dose of 1000 mg under controlled supervision produced an average hemoglobin increase of 1.75 g/dL (range 1.50–2.00 g/dL) and restored normal Hb concentrations in 86.41% of subjects.

These findings recommend that local health offices, Tualang Cut Public Health Center, and community midwifery practitioners integrate Moringa-based green medicine formulations as an alternative, safe, cost-effective, and impactful nutritional supplement program for adolescent nutritional recovery in disaster-prone and post-disaster areas.

The empirical findings of this study offer vital operational implications for post-disaster community midwifery practice and public health policy in disaster-prone regions. First, the administration of standardized Moringa oleifera leaf powder capsules (1,000 mg/day) provides community midwives with a safe, bioavailable, highly acceptable, and cost-effective "green medicine" alternative to conventional synthetic iron supplements, successfully eliminating gastrointestinal side effects and achieving exceptional compliance among adolescent girls (Sari, A. P., & Nurhayati, 2023). Second, these results advocate for a strategic paradigm shift in disaster recovery protocols—moving from passive emergency food distribution to active, nutraceutical-based adolescent micronutrient rehabilitation integrated within primary health centers (Puskesmas) and community posts (Posyandu). Third, utilizing locally cultivable botanical resources builds sustainable community self-reliance, empowering midwives and local health cares to deliver continuous, high-impact nutritional recovery without sole dependence on disrupted commercial supply chains (Khani Jeihooni et al., 2021)).

To conclusively establish the clinical non-inferiority or superiority of Moringa oleifera supplementation relative to standard iron therapy, rigorous multi-center, double-blind Randomized Controlled Trials (RCTs) are required. Future study designs should employ a three-arm parallel group structure comparing: (1) pure Moringa oleifera capsules, (2) standard synthetic Iron-Folic Acid (IFA) tablets, and (3) a combined low-dose IFA + Moringa formulation (Kumar et al., 2022; Moorthy et al., 2020). Moreover, intervention periods should be extended to 60–90 days, integrating advanced hematological biomarkers—including serum ferritin, soluble transferrin receptor (sTfR), total iron-binding capacity (TIBC), and high-sensitivity C-reactive protein (hs-CRP)—to track both functional hemoglobin recovery and body iron store replenishment (Khani Jeihooni et al., 2021). Quantitative monitoring of gastrointestinal side effects, patient-reported outcome measures (PROMs), and long-term compliance metrics should also be embedded to solidify the evidence base for Moringa-based green medicine in community midwifery practice (Setiadi, 2014).

ACKNOWLEDGEMENTS

The authors express their deepest gratitude to the Diploma-3 Midwifery Study Program, Faculty of Health, Universitas Satya Terra Bhinneka, for institutional support and research facilitation. Appreciation and thanks are also extended to the Head of Lhok Medang Ara Village, Kemukiman Tualang Cut, Aceh Tamiang Regency, the Head and Midwives of Tualang Cut Public Health Center, village health cadres, and all 187 adolescent girls and their families for their active participation in this study.

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