

Effect of a School-Based Nurse-Led Red Dragon Fruit Intervention as an Adjunct to Iron–Folic Acid Supplementation in Adolescent Girls: A Quasi-Experimental Study

Dwi Susanti^{1*}, Suwarno Suwarno¹, Suwarsi Suwarsi²

¹Department of Nursing, Universitas Jenderal Achmad Yani, Yogyakarta, 55294, Indonesia

²Department of Nursing, Universitas Respati, Yogyakarta, 55281, Indonesia

*Corresponding Author's Email: DwiSusanti@Unjaya.ac.id

ABSTRACT

Background: Background: Anemia remains a nutritional concern among adolescent girls, and routine Iron–Folic Acid (IFA) supplementation may benefit from complementary food-based strategies. **Objectives:** To examine whether adding 100 g of fresh red dragon fruit (*Hylocereus polyrhizus*) daily to routine IFA supplementation was associated with an additional change in hemoglobin levels among adolescent girls. **Methods:** A quasi-experimental pretest–posttest study with a non-equivalent control group was conducted among 96 adolescent girls in a public senior high school in Yogyakarta, Indonesia. Participants received routine IFA plus 100 g of fresh red dragon fruit daily for 14 days ($n = 48$) or routine IFA alone ($n = 48$). Hemoglobin was measured before and after the intervention. ANCOVA compared post-intervention hemoglobin between groups after adjustment for baseline hemoglobin, age, and menstrual cycle characteristics. **Results:** Hemoglobin increased by 0.274 g/dL in the intervention group and 0.145 g/dL in the control group. The unadjusted between-group difference in change was 0.129 g/dL (95% CI -0.036 to 0.294 ; $p = 0.123$). After adjustment, the estimated marginal means were 12.98 and 12.80 g/dL, respectively, with an adjusted difference of 0.18 g/dL (95% CI 0.04 – 0.32 ; $F(1,91) = 6.12$; $p = 0.015$; partial $\eta^2 = 0.06$). **Conclusion:** Adding fresh red dragon fruit to routine IFA supplementation was associated with a statistically significant but small adjusted difference in hemoglobin after 14 days. The findings should be interpreted cautiously because of the non-randomized design, short follow-up, and potential measurement uncertainty.

Keywords: Anemia; Dietary Intervention; Hemoglobin; Iron–Folic Acid Supplementation; Vitamin C

INTRODUCTION

Anemia remains an important public health concern among adolescent girls because rapid growth and menstrual blood loss increase iron requirements, while its etiology in Indonesian adolescents may involve multiple nutritional and contextual factors (Van Zutphen *et al.*, 2021). Low hemoglobin has been associated with fatigue, impaired concentration, and poorer quality of life, while iron deficiency during adolescence may extend into the reproductive years and affect later maternal health (Kolarš *et al.*, 2025; Raj *et al.*, 2025; Sari *et al.*, 2022). In Indonesia, the 2023 Indonesia Health Survey reported anemia prevalence of 15.5% among people aged 15–24 years and 18.0% among females in this age group, confirming that anemia remains relevant despite improvement from earlier national estimates (Ministry of Health of the Republic of Indonesia, 2024).

Weekly IFA supplementation remains a core strategy for preventing adolescent anemia in Indonesia (Sungkar *et al.*, 2022). However, implementation in school settings can be constrained by adherence and contextual barriers (Haile *et al.*, 2024; Hidayanty *et al.*, 2025; Wangaskar *et al.*, 2021). School nurses can support anemia prevention by reinforcing supplementation and providing practical dietary guidance. Food-based strategies are therefore of interest when they can be integrated into existing school health activities without replacing established IFA programs.

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Red dragon fruit (*Hylocereus polyrhizus*) is locally available in Indonesia and contains vitamin C, iron, phenolic compounds, and antioxidant constituents (Chen *et al.*, 2024; Shah *et al.*, 2023). Vitamin C can enhance non-heme iron absorption by promoting the reduction of ferric to ferrous iron, providing a plausible nutritional mechanism for combining vitamin C-containing foods with iron supplementation (Piskin *et al.*, 2022). However, the vitamin C content of red dragon fruit varies by cultivar and analytical conditions and is modest per 100-g serving (Chen *et al.*, 2024; Shah *et al.*, 2023). Thus, any additional hematological effect from a food portion should not be equated with the pharmacological doses of vitamin C used in supplementation trials.

Evidence specifically addressing red dragon fruit as an adjunct to routine IFA among adolescent girls remains limited. More broadly, randomized school-based food interventions have shown that fruit-based dietary strategies may influence hemoglobin or iron status, although findings cannot be directly extrapolated across different foods, populations, and intervention doses (Evang *et al.*, 2021). Existing local intervention reports have generally involved small samples, non-randomized designs, different formulations, or populations that are not directly comparable with school-based adolescent girls. Evidence on vitamin C added to oral iron is also mixed, with systematic evidence suggesting that the additional hematological benefit of vitamin C with iron supplementation remains uncertain (Deng *et al.*, 2024). A randomized clinical trial in adults with iron-deficiency anemia found that oral iron alone was equivalent to oral iron plus 200 mg vitamin C, indicating that additional vitamin C is not necessarily required for hematologic recovery (Li *et al.*, 2020). Evidence from dietary studies further indicates that the contribution of vitamin C to iron absorption depends on the dietary matrix, iron dose, timing, and underlying iron status (Skolmowska & Głabska, 2022; Von Siebenthal *et al.*, 2023).

Therefore, this study aimed to examine whether adding 100 g of fresh red dragon fruit daily to routine IFA supplementation was associated with an additional change in hemoglobin levels compared with routine IFA supplementation alone among adolescent girls in a school-based setting. The primary outcome was hemoglobin concentration; fruit-consumption compliance was recorded as an implementation measure, whereas acceptability, feasibility, sustainability, and longer-term adherence were outside the scope of the study.

METHODOLOGY

Study Design and Setting

This study employed a quasi-experimental pretest–posttest design with a non-equivalent control group. This design is appropriate for evaluating interventions in settings where individual randomization is not feasible and has been used as an established approach for intervention evaluation in healthcare research (Harris *et al.*, 2006). The design was chosen because random allocation was not feasible within the school setting due to administrative and scheduling constraints. The use of intact classes was intended to reduce potential intervention contamination between participants.

Four existing eleventh-grade classes that met the study eligibility criteria were identified in collaboration with the school administration. Based on the academic timetable and logistical feasibility, two intact classes were assigned to the intervention group and two to the control group. Assignment was determined administratively rather than by individual randomization to avoid disruption of routine classroom activities and reduce the risk of contamination between participants. The study was conducted at SMA Negeri 1 Godean in 2025, with a population of all 138 eleventh-grade female students.

Participants and Sampling

Total sampling was used within the selected classes. All students who met the eligibility criteria, consented to participate, and provided the required assent were recruited; therefore, the recruitment procedure was not purposive sampling.

Inclusion Criteria

Participants were eligible if they were female students in the selected eleventh-grade classes who had

begun menstruating, were routinely consuming IFA tablets, agreed to participate, and provided written parental or legal guardian consent and adolescent assent.

Exclusion Criteria

Participants were excluded if they had a known history of blood disorders or were experiencing acute illness at baseline that could affect hemoglobin status or interfere with participation in the intervention or hemoglobin assessment.

Sample Size Calculation

A formal sample-size calculation was performed using an independent two-group mean comparison, with a two-sided significance level of 0.05, 80% statistical power, and an anticipated standardized between-group effect size of $d = 0.60$. This yielded a minimum sample of 90 participants (45 per group). A total of 96 eligible students were recruited and completed the study. The anticipated effect size was a planning assumption rather than an observed effect. The observed within-group standardized effects were smaller ($d = 0.16$ in the intervention group and $d = 0.12$ in the control group), and the study was therefore not specifically powered to detect effects of that magnitude.

Because participants were allocated by four intact classes, the sample-size calculation did not incorporate a cluster design effect. The statistical analysis was conducted at the individual participant level rather than using a multilevel or cluster-adjusted model. Potential within-class correlation may therefore have resulted in underestimated standard errors and was considered when interpreting the findings.

Data Collection

The instruments included a demographic questionnaire assessing age, age at menarche, and menstrual cycle, and the Easy Touch GCHb hemoglobin meter. The device was selected because it is a portable point-of-care instrument suitable for field-based hemoglobin assessment. The device was operated according to the manufacturer's instructions, using compatible test strips and capillary blood samples. Before measurement, the device and test strips were checked for proper operation, expiration status, and physical integrity. Before each testing session, the device was prepared according to the manufacturer's instructions, and the code chip corresponding to the test-strip batch was inserted into the device. The supplied standard optical check strip was used to verify device operation before participant measurements.

Researchers conducted an orientation session to explain the study purpose and procedures, and participants completed the required consent and demographic forms. Baseline hemoglobin was measured in both groups before intervention delivery. Post-intervention hemoglobin was measured on day 15, immediately after completion of the 14-day intervention period.

As most participants were aged 15–17 years, written informed consent was obtained from parents or legal guardians, and written adolescent assent was obtained before enrollment and before any study procedures were conducted.

Intervention Procedure

The intervention was delivered over 14 consecutive days. The intervention group received 100 g of fresh red dragon fruit daily at 09:00 WIB in addition to routine IFA supplementation, consisting of one tablet weekly and one tablet daily during menstruation. The control group received IFA supplementation alone.

The intervention was nurse-led and implemented within the school setting. The research nurse coordinated participant recruitment and orientation with the school, provided standardized information regarding the intervention and IFA supplementation, supervised daily consumption of red dragon fruit, monitored attendance and consumption, reinforced adherence to the intervention protocol, and followed up with participants who

missed scheduled intervention sessions. Hemoglobin measurements were performed by trained research personnel using the standardized measurement procedure described above.

The intervention was implemented within the school setting under the supervision of the research team. Daily fruit consumption was directly observed and recorded using attendance checklists. Participants missing more than two consecutive days were followed up individually. IFA intake followed routine school monitoring procedures and was documented through weekly verification.

Potential Confounding Factors

Inflammatory markers were not measured because of logistical and budgetary limitations. Dietary intake outside the intervention was not strictly controlled, and participants were instructed to maintain their usual eating patterns during the study period.

Statistical Analysis

Data were analyzed using SPSS. Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages.

Baseline characteristics were compared between groups using independent-samples t-tests for continuous variables and chi-square tests for categorical variables, as appropriate. Normality of continuous variables was assessed using the Shapiro–Wilk test. Paired-samples t-tests were used to examine within-group changes in hemoglobin levels from pretest to posttest. An independent-samples t-test was used to compare individual changes in hemoglobin (ΔHb) between groups. The primary adjusted between-group inferential analysis was ANCOVA, comparing post-intervention hemoglobin between groups with study group as the fixed factor and baseline hemoglobin, age, and menstrual cycle characteristics as covariates.

ANCOVA was performed with post-intervention hemoglobin as the dependent variable and study group as the fixed factor. Baseline hemoglobin was entered as a continuous covariate, age was entered as a continuous variable, and menstrual cycle characteristics were coded as a binary variable (0 = not normal; 1 = normal). Age and menstrual cycle characteristics were included as prespecified covariates because of their potential relevance to adolescent hemoglobin status and menstrual blood loss, with menstrual cycle characteristics also showing a baseline between-group difference.

ANCOVA Assumption Testing

The assumptions of ANCOVA were assessed before interpretation. Linearity was evaluated by examining scatter plots of baseline hemoglobin and age against post-intervention hemoglobin. Normality of the ANCOVA residuals was evaluated using the Shapiro–Wilk test, homogeneity of variance using Levene's test, and homogeneity of regression slopes by testing the interaction between study group and each covariate. The ANCOVA model was interpreted only after the relevant assumptions were adequately met.

Effect sizes were expressed using Cohen's d for within-group changes and partial eta squared (η^2) for ANCOVA effects. Ninety-five percent confidence intervals were reported where applicable.

Consideration of Clustering

Because participants were assigned by four intact classes, the potential for within-class clustering was recognized. However, the primary analyses were conducted at the individual participant level and did not use a multilevel model, generalized estimating equations, or cluster-robust standard errors. As only four classes were involved, a cluster-adjusted analysis was not undertaken. Consequently, possible dependence among participants within the same class remains a limitation and may have resulted in underestimated standard errors. The findings were therefore interpreted cautiously.

Ethical Considerations

The research obtained ethical approval from the Research Ethics Committee of the Faculty of Health,

Jenderal Achmad Yani University Yogyakarta, Indonesia with ethical approval number Skep/484/KEP/VIII/2025 on 2nd August 2025.

Before enrollment, the purpose of the study, procedures, potential benefits and participation requirements were explained to participants and their parents or legal guardians. Written informed consent was obtained from parents or legal guardians, and written adolescent assent was obtained from participants. Participation was voluntary, and participants could withdraw at any time without penalty. Participant information was kept confidential and used solely for research purposes.

RESULTS

A total of 96 students participated in the study, comprising 48 respondents in the intervention group and 48 in the control group. Baseline characteristics are presented in Table 1. Age and menstrual cycle characteristics differed between groups, whereas age at menarche and baseline hemoglobin did not. Age and menstrual cycle characteristics differed between groups and were included as covariates in the adjusted ANCOVA model.

Table 1: Characteristics of Respondents in the Intervention and Control Groups (n = 96)

Characteristic	Intervention (n=48)	Control (n=48)	Test statistic (df)	p
Age, n (%)			$\chi^2 (2) = 0.552$	0.759
15 years	1 (2.1)	1 (2.1)		
16 years	35 (72.9)	38 (79.2)		
17 years	12 (25.0)	9 (18.8)		
Age at Menarche, n (%)			$\chi^2 (3) = 0.716$	0.869
10 years	2 (4.2)	3 (6.3)		
11 years	11 (22.9)	8 (16.7)		
12 years	26 (54.2)	26 (54.2)		
13 years	9 (18.7)	10 (20.8)		
Menstrual Cycle, n (%)			$\chi^2 (1) = 9.503$	0.002
Normal	26 (54.2)	40 (83.3)		
Not normal	22 (45.8)	8 (16.7)		
Baseline Hb, Mean $\pm$ SD (g/dL)	12.84 $\pm$ 1.92	12.49 $\pm$ 1.26	$t (94) = 1.06$	0.294

Hemoglobin levels increased in both groups following the 14-day intervention (Table 2). In the intervention group, mean hemoglobin increased from 12.84 $\pm$ 1.92 g/dL to 13.08 $\pm$ 1.03 g/dL, representing a mean increase of 0.274 g/dL (paired $t = 3.324$, $df = 47$, $p = 0.002$; 95% CI 0.108–0.439; Cohen's $d = 0.16$). In the control group, mean hemoglobin increased from 12.49 $\pm$ 1.26 g/dL to 12.63 $\pm$ 1.12 g/dL, corresponding to a mean increase of 0.145 g/dL (paired $t = 13.261$, $df = 47$, $p < 0.001$; 95% CI 0.123–0.167; Cohen's $d = 0.12$). The unadjusted difference in mean change between groups was 0.129 g/dL, and the independent-samples test of individual Δ Hb showed no statistically significant difference ($t = 1.555$, $df = 94$, $p = 0.123$; 95% CI –0.036 to 0.294).

The intervention group had an overall fruit-consumption compliance of 94.6%. Baseline hemoglobin values in this group ranged from 7.7 to 17.9 g/dL; all observations were retained in the analysis without post-hoc deletion or modification.

Table 2: Pre- and Post-intervention Hemoglobin Levels in the Intervention and Control Groups (n = 96)

Group	Variable	Min	Max	Mean $\pm$ SD	Mean Difference	95% CI for Mean Difference	p-value	Within-group Cohen's d
Intervention	Pretest	7.7	17.9	12.84 $\pm$ 1.92	0.274	0.108 to 0.439	0.002	0.16
	Posttest	11.4	16.3	13.08 $\pm$ 1.03				
Control	Pretest	9.9	14.9	12.49 $\pm$ 1.26	0.145	0.123 to 0.167	<0.001	0.12
	Posttest	9.8	15.5	12.63 $\pm$ 1.12				

As shown in table 3(a) and 3(b) after adjustment for baseline hemoglobin level, age, and menstrual cycle characteristics, ANCOVA showed a significant group effect on post-intervention hemoglobin ($F(1,91) = 6.12$, $p = 0.015$, partial $\eta^2 = 0.06$). Baseline hemoglobin was also significantly associated with post-intervention hemoglobin ($F(1,91) = 4.45$, $p = 0.038$, partial $\eta^2 = 0.05$), whereas age ($F(1,91) = 0.13$, $p = 0.720$, partial $\eta^2 < 0.01$) and menstrual cycle characteristics ($F(1,91) = 0.27$, $p = 0.605$, partial $\eta^2 < 0.01$) were not. The estimated marginal mean was 12.98 g/dL (SE = 0.16; 95% CI 12.66–13.30) in the intervention group and 12.80 g/dL (SE = 0.16; 95% CI 12.48–13.12) in the control group, yielding an adjusted between-group difference of 0.18 g/dL (95% CI 0.04–0.32).

Table 3(a): ANCOVA of Post-intervention Hemoglobin

Source	df	F	p	Partial η^2
Baseline Hb	1,91	4.45	0.038	0.05
Age	1,91	0.13	0.720	<0.01
Menstrual cycle	1,91	0.27	0.605	<0.01
Group	1,91	6.12	0.015	0.06

Note: ANCOVA model: post-intervention hemoglobin was the dependent variable; study group was the fixed factor; baseline hemoglobin, age, and menstrual cycle characteristics were covariates.

Table 3(b): Estimated Marginal Means

Group	Adjusted Mean (SE), g/dL	95% CI
Intervention	12.98 (0.16)	12.66–13.30
Control	12.80 (0.16)	12.48–13.12

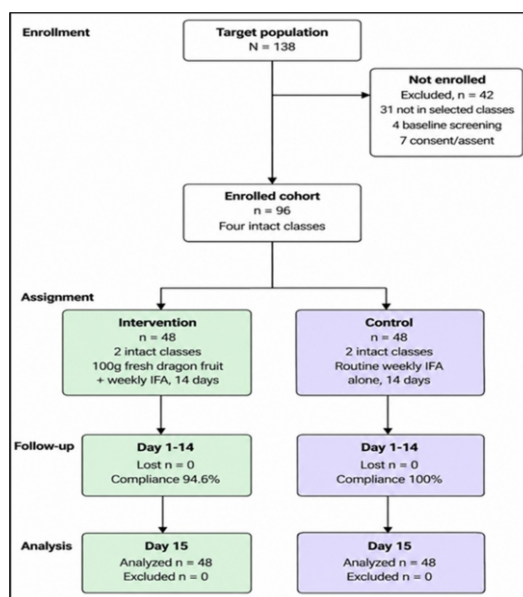


Figure 1: Flow diagram of participant recruitment and allocation in a non-randomized study of fresh dragon fruit supplementation combined with weekly IFA versus routine IFA alone

DISCUSSION

The principal finding was a small, adjusted difference in post-intervention hemoglobin favoring the group that received 100 g of fresh red dragon fruit daily in addition to routine IFA. Mean hemoglobin increased by 0.274 g/dL in the intervention group and 0.145 g/dL in the control group, with an adjusted between-group difference of 0.18 g/dL. Importantly, the unadjusted comparison of individual ΔHb was not statistically significant ($p = 0.123$). Thus, the statistically significant ANCOVA result should not be interpreted as evidence of a large or clinically important hematological effect. The standardized within-group effects were also small ($d = 0.16$ and 0.12), and the brief intervention and non-randomized design further limit causal interpretation. The wide baseline hemoglobin range observed in the intervention group also warrants cautious interpretation of the estimated effect.

One possible explanation for the observed difference is the nutritional composition of red dragon fruit. *H. polyrhizus* contains vitamin C, iron, phenolic compounds, and antioxidant constituents (Chen *et al.*, 2024; Shah *et al.*, 2023). Vitamin C can facilitate non-heme iron absorption, providing a biologically plausible mechanism for a food-based adjunct to IFA (Piskin *et al.*, 2022). However, the vitamin C supplied by 100 g of fresh fruit is substantially lower than doses used in trials of vitamin C supplementation. Li *et al.* (2020), for example, evaluated 200 mg of vitamin C combined with oral iron in adults with iron-deficiency anemia, whereas the present intervention used a food portion with a more modest and variable vitamin C content. The observed difference therefore should not be interpreted as evidence of a vitamin C dose-response effect and may reflect the whole-food intervention or other contextual factors.

The comparison with previous evidence also requires consideration of differences in study design and population. Li *et al.* (2020) conducted a randomized clinical trial and found that oral iron alone was equivalent to oral iron plus 200 mg vitamin C for hemoglobin recovery in adults with iron-deficiency anemia; their findings therefore do not support a routine requirement for additional vitamin C. This is consistent with recent clinical guidance summarized by García-Erce *et al.* (2026), which notes that the European Hematology Association does not recommend routine vitamin C co-administration with oral iron because available evidence has not demonstrated additional hematological benefit. Evidence from dietary studies similarly indicates that the contribution of vitamin C to iron absorption depends on the dietary matrix, iron dose, timing, and underlying iron status (Skolmowska & Głowska, 2022; Von Siebenthal *et al.*, 2023). Recent evidence synthesis likewise indicates that an incremental benefit of vitamin C when combined with oral iron is not consistently demonstrated (Deng *et al.*, 2024). Accordingly, the present finding is better viewed as a modest empirical signal associated with a whole-food adjunct rather than as evidence of a vitamin C-mediated mechanism or superiority over IFA.

From a school-nursing perspective, the immediate implication is that locally available food could be incorporated into nutrition counseling or school-based anemia-prevention activities as a complementary option while routine IFA remains the established preventive strategy. The observed fruit-consumption compliance of 94.6% indicates that the intervention could be delivered under direct school supervision during the study period. This finding reflects short-term observed compliance during the supervised intervention and should not be interpreted as evidence of long-term adherence.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the quasi-experimental design and nonrandom allocation of intact classes may have introduced selection bias and residual confounding. Although baseline hemoglobin, age, and menstrual cycle characteristics were included in the adjusted analysis, statistical adjustment cannot fully substitute for randomization. In addition, participants were assigned through four intact classes, whereas the analysis was conducted at the individual level without multilevel modeling or cluster-robust adjustment. Potential within-class correlation may therefore have resulted in underestimated standard errors.

The intervention was conducted in a single school with a relatively small sample, which may limit the generalizability of the findings to adolescent girls in other schools, communities, or geographic settings. The intervention lasted only 14 days, which limits the ability to determine whether the observed change in hemoglobin would be sustained over a longer period. Dietary intake outside the intervention was not strictly controlled, and inflammatory biomarkers were not measured; therefore, other dietary and physiological factors that may have influenced hemoglobin levels could not be fully assessed.

The range of hemoglobin was measured using a point-of-care device rather than a laboratory-based reference method. The intervention group also showed a wide baseline hemoglobin range of 7.7–17.9 g/dL, with the standard deviation decreasing from 1.92 g/dL at baseline to 1.03 g/dL after the intervention. Because duplicate laboratory confirmation and independent verification of unusual values were unavailable, it was not possible to determine whether these observations reflected true biological variation, measurement-related limitations, or observer-related error. The values were retained without post hoc modification; however, this measurement uncertainty should be considered when interpreting the small adjusted between-group

difference. In addition, iron-status biomarkers such as serum ferritin were not available, limiting the ability to determine whether changes in hemoglobin were accompanied by improvements in underlying iron status.

The study did not evaluate acceptability, affordability, feasibility, sustainability, or long-term adherence. The observed 94.6% compliance represented short-term fruit consumption under direct supervision during the 14-day intervention and should not be interpreted as evidence of sustained adherence under routine school conditions. Future studies should incorporate longer follow-up periods and implementation-related outcomes to better evaluate the practicality and sustainability of the intervention.

Future Scope

Future studies should use randomized or cluster-randomized designs with adequate sample sizes and appropriate cluster-adjusted or multilevel analyses. Longer intervention and follow-up periods should be incorporated laboratory-based iron-status and inflammatory biomarkers together with strengthened hemoglobin measurement-quality procedures. Research should also evaluate implementation outcomes, particularly long-term adherence, acceptability, feasibility, and sustainability, to determine the potential integration of daily red dragon fruit consumption into routine school-based anemia-prevention programs.

CONCLUSION

This study found that adding fresh red dragon fruit to routine IFA supplementation was associated with a modest increase in hemoglobin levels among adolescent girls after adjustment for baseline hemoglobin level, age, and menstrual cycle characteristics. The findings suggest that locally available foods may be considered as a complementary nutritional strategy within existing school health services, while routine IFA supplementation remains the standard approach. Because this study evaluated hemoglobin outcomes only, no conclusions can be drawn regarding adherence, feasibility, or long-term implementation. Further studies using randomized designs, longer follow-up periods, and multiple settings are needed to confirm these findings and to examine implementation-related outcomes in routine nursing practice.

CRedit Authorship Contribution Statement

D.S: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Writing – Review and Editing, Project Administration. S. Suwarno: Methodology, Investigation, Data Curation, Validation, Writing – Review and Editing. S. Suwarsi: Supervision, Validation, Writing – Review and Editing, Project Administration.

AI Assistance Declaration

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) solely to support language editing and grammar refinement. The use of this tool was limited to improving the clarity and readability of the manuscript and did not involve data analysis, interpretation of findings, or the development of scientific conclusions. All manuscript content was critically reviewed and revised by the authors, who take full responsibility for the accuracy, originality, and integrity of the final manuscript.

Conflict of Interest

The authors declare no potential conflicts of interest in this research or manuscript.

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REFERENCES

- Chen, S. Y., Xu, C. Y., Mazhar, M. S., & Naiker, M. (2024). Nutritional value and therapeutic benefits of dragon fruit: A comprehensive review with implications for establishing Australian industry standards. *Molecules*, 29(23), 5676. <https://doi.org/10.3390/molecules29235676>
- Deng, J., Ramelli, L., Li, P. Y., Eshaghpour, A., Li, A., Schuenemann, G., & Crowther, M. A. (2024). Efficacy of vitamin C with Fe supplementation in patients with iron deficiency anemia: a systematic review and meta-analysis. *Blood Vessels, Thrombosis & Hemostasis*, 1(4), 100023. <https://doi.org/10.1016/j.bvth.2024.100023>
- Evang, E. C., Habte, T. Y., Owino, W. O., & Krawinkel, M. B. (2021). Can the supplementary consumption of baobab (*Adansonia digitata* L.) fruit pulp improve the hemoglobin levels and iron status of schoolchildren in Kenya? Findings of a randomized controlled intervention trial. *European Journal of Nutrition*, 60(5), 2617–2629. <https://doi.org/10.1007/s00394-020-02447-2>
- García-Erce, J. A., García-López, S., & Martínez-Francés, A. (2026). Iron deficiency and oral treatments: Limitations, pharmacokinetics, and the role of iron protein succinylate in clinical practice. *Journal of Clinical Medicine*, 15(10), 3691. <https://doi.org/10.3390/jcm15103691>
- Haile, B., Oumer, A., Negese, T., Temesgen, M., Kebede, A., Abdurahman, D., ... & Roba, K. T. (2024). Factors associated with compliance with weekly iron and folic acid supplementation among school adolescent girls in Debub Achefer district, northwest Ethiopia: school-based cross-sectional study. *Scientific Reports*, 14(1), 9980. <https://doi.org/10.1038/s41598-024-60800-5>
- Harris, A. D., McGregor, J. C., Perencevich, E. N., Furuno, J. P., Zhu, J., Peterson, D. E., & Finkelstein, J. (2006). The use and interpretation of quasi-experimental studies in medical informatics. *Journal of the American Medical Informatics Association*, 13(1), 16–23. <https://doi.org/10.1197/jamia.M1749>
- Hidayanty, H., Nurzakiah, N., Irmayanti, I., Yuliana, Y., Helmizar, H., & Yahya, Y. (2025). Perceived barriers and enablers for taking iron–folic acid supplementation regularly among adolescent girls in Indonesia: A pilot study. *International Journal of Environmental Research and Public Health*, 22(2), 209. <https://doi.org/10.3390/ijerph22020209>
- Kolarš, B., Mijatović J. V., Živanović, N., Minaković, I., Gvozdenović, N., Dickov K. I., & Lesjak, M. (2025). Iron deficiency and iron deficiency anemia: a comprehensive overview of established and emerging concepts. *Pharmaceuticals*, 18(8), 1104. <https://doi.org/10.3390/ph18081104>
- Li, N., Zhao, G., Wu, W., Zhang, M., Liu, W., Chen, Q., & Wang, X. (2020). The efficacy and safety of vitamin C for iron supplementation in adult patients with iron deficiency anemia: a randomized clinical trial. *JAMA Network Open*, 3(11), e2023644. <https://doi.org/10.1001/jamanetworkopen.2020.23644>
- Ministry of Health of the Republic of Indonesia, Health Development Policy Agency. (2024). *Indonesian Health Survey 2023 in numbers*. <https://www.badankebijakan.kemkes.go.id/en/repositori/id/eprint/5538/>
- Piskin, E., Cianciosi, D., Gulec, S., Tomas, M., & Capanoglu, E. (2022). Iron absorption: factors, limitations, and improvement methods. *ACS Omega*, 7(24), 20441. <https://doi.org/10.1021/acsomega.2c01833>
- Raj, R., Menon, N., & Srivaths, L. (2025). Iron deficiency and anemia in menstruating adolescents. *Pediatrics In Review*, 46(11), 606–616. <https://doi.org/10.1542/pir.2025-006756>
- Sari, P., Herawati, D. M. D., Dhamayanti, M., & Hilmanto, D. (2022). Anemia among adolescent girls in west java, Indonesia: related factors and consequences on the quality of life. *Nutrients*, 14(18), 3777. <https://doi.org/10.3390/nu14183777>
- Shah, K., Chen, J., Chen, J., & Qin, Y. (2023). Pitaya nutrition, biology, and biotechnology: A review. *International Journal of Molecular Sciences*, 24(18), 13986. <https://doi.org/10.3390/ijms241813986>

- Skolmowska, D., & Głabska, D. (2022). Effectiveness of dietary intervention with iron and vitamin C administered separately in improving iron status in young women. *International Journal of Environmental Research and Public Health*, 19(19), 11877. <https://doi.org/10.3390/ijerph191911877>
- Sungkar, A., Bardosono, S., Irwinda, R., Manikam, N. R., Sekartini, R., Medise, B. E., ... & Vandenplas, Y. (2022). A life course approach to the prevention of iron deficiency anemia in Indonesia. *Nutrients*, 14(2), 277. <https://doi.org/10.3390/nu14020277>
- Van Zutphen, K. G., Kraemer, K., & Melse-Boonstra, A. (2021). Knowledge gaps in understanding the etiology of anemia in Indonesian adolescents. *Food and Nutrition Bulletin*, 42(1_suppl), S39-S58. <https://doi.org/10.1177/0379572120979241>
- Von Siebenthal, H. K., Moretti, D., Zimmermann, M. B., & Stoffel, N. U. (2023). Effect of dietary factors and time of day on iron absorption from oral iron supplements in iron deficient women. *American Journal of Hematology*, 98(9), 1356-1363. <https://doi.org/10.1002/ajh.26987>
- Wangaskar, S. A., Sahu, S. K., Majella, M. G., & Rajaa, S. (2021). Prevalence of anaemia and compliance to weekly iron-folic acid supplementation programme amongst adolescents in selected schools of urban Puducherry, India. *Nigerian Postgraduate Medical Journal*, 28(1), 44-50. https://doi.org/10.4103/npmj.npmj_336_20