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SiMerah Digital Monitoring of Iron–Folic Acid Supplementation Adherence Among Adolescent Girls: A Quasi-Experimental Study

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ABSTRACT

Background: Adherence to weekly iron-folic acid supplementation remains an important challenge in anemia-prevention programs for adolescent girls. Recent Indonesian evidence suggests that adherence is influenced by individual, peer, school, and program-delivery factors, while digital reminder interventions may improve supplementation behavior. SiMerah (Skrining Anemia pada Remaja Sehat) is a web-based digital application developed to support scheduled reminders, consumption recording, adherence monitoring, and validation of evidence of tablet intake.

Purpose: To evaluate adherence outcomes associated with SiMerah digital monitoring compared with routine school-based monitoring.

Methods: A two-group quasi-experimental pre-test–post-test study involved 186 adolescent girls (93 per group) at SMK Karya, Kediri, Indonesia. Adherence was calculated as the proportion of five scheduled weekly tablets recorded as consumed during each assessment period. Within-group paired tests, between-group comparison of change, and exploratory baseline-adjusted linear regression with heteroskedasticity-robust standard errors were performed.

Results: Mean adherence changed from 97.85% to 96.13% in the SiMerah group and from 92.04% to 89.25% in the comparison group. The between-group difference in change was 1.08 percentage points (95% CI -2.71 to 4.86; p=0.575). Baseline adherence differed between groups (p<0.001). Exploratory baseline-adjusted analysis showed a post-test difference of 5.16 points (95% CI 1.81 to 8.51; p=0.003), but the observational design and baseline imbalance limit causal interpretation.

Conclusion: The SiMerah group did not show a statistically significant improvement in recorded adherence relative to routine monitoring when comparing pre–post changes. High initial adherence, baseline imbalance, and strong existing school health monitoring warrant cautious interpretation. Future versions should evaluate post-consumption symptoms and usability.

Keywords : Adolescent Girls, Adherence, Anemia, Iron-Folic Acid Supplementation

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BACKGROUND

Anemia among adolescent girls remains an important public health concern because adolescence is a period of rapid growth and increasing iron requirements. School-based weekly iron-folic acid supplementation is one of the strategies used to prevent anemia among adolescent girls; however, the effectiveness of supplementation programs depends substantially on whether the tablets are actually consumed as recommended. The World Health Organization recommends intermittent iron and folic acid supplementation in relevant populations to improve iron status and reduce anemia risk (World Health Organization, 2011).

Recent evidence from Indonesian school settings indicates that adherence remains suboptimal. In a 2026 evaluation involving 694 schoolgirls from selected schools in East Java and Bali, the mean adherence to school-based iron supplementation was 40%. Adherence was associated not only with individual factors such as attitude and peer support, but also with school type, location, and the mechanism used to distribute and administer iron tablets (Setiadi et al., 2026). These findings suggest that adherence is a behavioral and implementation problem that requires structured support and monitoring rather than tablet distribution alone. Earlier Indonesian school-based research also documented gaps in supplementation coverage and adherence (Alfiah et al., 2020). A systematic review identified personal, social, environmental, and regimen-related determinants (Silitonga et al., 2023).

Digital health approaches offer an opportunity to strengthen reminder, recording, and monitoring mechanisms. In Maluku, Indonesia, a quasi-experimental study reported that WhatsApp-based reminder messages improved knowledge and weekly iron-folic acid supplementation adherence among adolescent girls compared with routine services (Laurence et al., 2025). More recently, the Jaga Diri digital intervention was reported to improve knowledge and adherence to weekly iron-folic acid supplementation among adolescent girls in Maluku Province (Pasamba et al., 2026). Together, these studies support the potential role of digital interventions in strengthening supplementation behavior among Indonesian adolescents. Reviews of adolescent-focused digital interventions report promising feasibility, although adherence effects vary across settings (Badawy & Kuhns, 2017; Badawy et al., 2017).

Nevertheless, a reminder message alone does not provide a complete monitoring pathway. A digital intervention that combines scheduled reminders with individual consumption recording, administrator monitoring, and validation of evidence of tablet intake may offer a more structured approach. SiMerah (Skrining Anemia pada Remaja Sehat) was therefore developed as a web-based application to support adherence monitoring among adolescent girls. At the current stage of this study, the administrator module includes Login, Dashboard, Class Data, Student Data, Reminder Schedule, Adherence Monitoring, and Validation of Evidence of Intake. The SiMerah application was intended for use during the post-test monitoring period after baseline assessment. [AUTHOR TO VERIFY: actual deployment date, active modules, and evidence from system logs.]

The scientific contribution is an assessment of whether adding digital adherence documentation to an already supervised school supplementation program is associated with a different adherence trajectory, rather than assuming that reminders alone produce additional

gains. This study therefore compared changes in documented weekly iron–folic acid supplementation adherence between SiMerah monitoring and routine school-based monitoring.

METHODS

Design and Setting

This study used a non-randomized quasi-experimental two-group pre-test–post-test design. The unit of analysis was the individual student. Both groups had five scheduled tablet opportunities during each measurement period.

Study Setting and Period

The study took place at SMK Karya, Wates District, Kediri Regency, Indonesia, in 2026. The supplementation schedule followed the existing Puskesmas–School Health Unit (UKS) program.

Participants and Sampling

Proportionate stratified random sampling was used to select participants, with classes serving as sampling strata. Students were sampled proportionally from each class to ensure representation across classes. The analytic dataset included 186 adolescent girls, comprising 93 participants in the SiMerah intervention group and 93 in the comparison group.

Intervention and Comparison Conditions

The local Puskesmas coordinated routine iron–folic acid tablet distribution with the school UKS. The UKS involved teachers, one nurse, and student supervisors who observed consumption and recorded it on Kartu TTD. The SiMerah group used digital adherence monitoring in addition to the existing supplementation program; the comparison group used conventional monitoring. Puskesmas staff also delivered anemia and tablet-consumption education at the start of implementation.

SiMerah was developed as a web-based system for consumption recording and monitoring, with administrator functions including class/student records, reminder scheduling, adherence monitoring, and evidence validation. Both the intervention and comparison groups received health education and assistance regarding anemia prevention and iron-folic acid (IFA) supplementation, facilitated by healthcare professionals from the local community health center (Puskesmas) in collaboration with the School Health Unit (UKS). The educational activities and routine supplementation program were provided to both groups. The primary difference between the groups was the adherence monitoring method: the intervention group used the SiMerah digital application, whereas the comparison group continued using conventional IFA monitoring cards (Kartu TTD).

Intervention Procedures

The pre-test assessment was conducted from August 14 to September 11, 2026, followed by the post-test assessment from September 18 to October 13, 2026. Iron-folic acid (IFA) supplementation was implemented as part of the routine school-based supplementation program coordinated by the local community health center (Puskesmas) in collaboration with the School Health Unit (UKS) at SMK Karya. Each participant was scheduled to consume one IFA tablet per week, containing 60 mg of elemental iron and 400 µg of folic acid. Supplementation was

generally conducted on Fridays under the supervision of the school health team. During the final week of the post-test period, the supplementation schedule was adjusted to Tuesday, October 13, 2026, coinciding with a health education and assistance session delivered by healthcare professionals from the Puskesmas.

Both the intervention and comparison groups received health education and assistance related to anemia prevention and IFA supplementation. The primary difference between the groups was the adherence monitoring method. The intervention group used the SiMerah digital application to document IFA consumption, whereas the comparison group continued using conventional IFA monitoring cards (Kartu TTD). Adherence was assessed based on the proportion of scheduled IFA tablets documented as consumed during the respective observation periods.SiMerah Application

The prototype administrator interface included login, dashboard, class data, student data, reminder schedule, adherence monitoring, and evidence-validation modules. These are documented development features; their actual deployment and use during this study must be confirmed from implementation logs.

Instruments and Data Collection

Adherence to iron-folic acid (IFA) supplementation was assessed based on the number of tablets documented as consumed relative to the number of scheduled doses during each observation period. The supplementation program was coordinated by the local community health center (Puskesmas) and implemented with support from the School Health Unit (UKS), involving teachers, a nurse, and student supervisors. The pre-test assessment was conducted from August 14 to September 11, 2026, while the post-test assessment was conducted from September 18 to October 13, 2026. Both periods included five scheduled supplementation opportunities. During the final week of the post-test period, the supplementation schedule was adjusted to October 13, 2026, to coincide with an educational and assistance session facilitated by healthcare professionals from the Puskesmas.

Adherence data were documented using the SiMerah digital application in the intervention group and conventional IFA monitoring cards (Kartu TTD) in the comparison group. Individual adherence percentages were calculated by dividing the number of documented tablets consumed by the number of scheduled tablets and multiplying by 100.

Data Analysis

Descriptive statistics are presented as mean ± standard deviation for adherence percentage and frequency for age and grade. Paired t-tests describe within-group change. Welch independent-samples t-tests compare baseline scores and pre–post change between groups; the latter is the unadjusted primary comparison. Given baseline imbalance, exploratory ANCOVA-type ordinary least squares regression estimated post-test adherence differences adjusted for pre-test adherence, with HC3 robust standard errors. All tests were two-sided, with 95% confidence intervals. Although the theoretical adherence scale comprises 0%, 20%, 40%, 60%, 80%, and 100%, the supplied analytic dataset contained only 60%, 80%, and 100% and shows a ceiling effect, parametric inferences should be considered cautiously. No causal claim is based solely on the adjusted model.

The primary estimand was the unadjusted between-group difference in pre–post change. A separate baseline-adjusted post-test model was considered exploratory because it estimates a different association and cannot eliminate confounding from nonrandom allocation. Statistical analyses were performed using IBM SPSS Statistics, version 32.0 (IBM Corp., Armonk, NY, USA). All statistical tests were two-sided, with a significance level of 0.05.

RESULTS

The analytic recap contained 186 rows with usable pre-test and post-test tablet counts: 93 in the SiMerah group and 93 in the comparison group. Each participant had five scheduled doses per period. No duplicate IDs, missing key outcome values, or consumed counts exceeding scheduled counts were identified in the supplied workbook. These statements concern the analytic spreadsheet, not independently verified participant retention.

Pre-test adherence was higher in the SiMerah group than in the comparison group. Adherence decreased slightly in both groups, and the unadjusted between-group difference in change was not statistically significant. Exploratory adjustment for baseline adherence yielded a positive association with post-test adherence, which requires cautious interpretation.

Table 1. Participant flow and study completion

Study stage	Intervention group, n	Comparison group, n	Total, n
Recruited/enrolled (per recap)	93	93	186
Complete pre-test records	93	93	186
Complete post-test records	93	93	186
Included in analytic dataset	93	93	186

Values are based on the supplied 186-participant research-team recap; source-data and protocol checks remain necessary.

Table 2. Baseline characteristics of participants

Characteristic	Intervention group	Comparison group	p-value
Age, years, mean ± SD	16.69 ± 0.79	16.91 ± 0.93	Descriptive
Grade X / XI / XII, n	42 / 35 / 16	32 / 27 / 34	Descriptive
Baseline adherence %, mean ± SD	97.85 ± 6.89	92.04 ± 13.23	0.00026
Age 15 / 16 / 17 / 18, n	3 / 39 / 35 / 16	6 / 26 / 31 / 30	Descriptive

Values are based on the supplied 186-participant research-team recap; source-data and protocol checks remain necessary.

Table 3. Pre-test and post-test adherence within groups

Group	Pre-test	Post-test	Change	p-value
SiMerah intervention	97.85 ± 6.89	96.13 ± 8.97	-1.72 ± 10.07	0.103
Routine monitoring	92.04 ± 13.23	89.25 ± 13.04	-2.80 ± 15.49	0.085

Values are based on the supplied 186-participant research-team recap; source-data and protocol checks remain necessary.

Table 4. Between-group comparison of change in adherence

Outcome	Intervention group	Comparison group	Effect estimate (95% CI)	p-value
Change in adherence (percentage points)	-1.72 ± 10.07	-2.80 ± 15.49	1.08 (-2.71 to 4.86)	0.575
Adjusted post-test difference (exploratory)	Adjusted for baseline	Reference	5.16 (1.81 to 8.51)	0.003

Table 4 note: Positive estimates favor SiMerah. Change comparison uses Welch t-test; adjusted estimate uses HC3-robust OLS with baseline adherence as a covariate. Percentages reflect five scheduled tablets per period. Values are based on the supplied 186-participant research-team recap; source-data and protocol checks remain necessary.

DISCUSSION

The results support a cautious assessment of digital monitoring as an addition to an established school health program rather than a stand-alone solution for adherence.

Principal Findings

The SiMerah group had very high pre-test adherence (97.85%) and a small mean decline of 1.72 percentage points, compared with a 2.80-point decline in the conventional monitoring group. The unadjusted difference in change was 1.08 points (95% CI -2.71 to 4.86; p=0.575), providing insufficient evidence of a differential improvement. Baseline adherence was materially higher in the SiMerah group, and an exploratory regression adjusted for baseline suggested higher post-test adherence associated with SiMerah (difference 5.16 points; 95% CI 1.81–8.51; p=0.003). This adjusted association should not be described as proof of efficacy because the groups were not established as exchangeable and educational co-interventions remain to be verified.

Comparison With Previous Studies

Earlier digital reminder and adherence studies cited in the background suggest that technology can support supplementation programs. In contrast, the present study was implemented in a school where supervised Friday consumption and immediate Kartu TTD documentation were already routine. High baseline adherence may have restricted detectable gains. Comparisons with prior studies must consider intervention intensity, baseline adherence, and outcome definitions; cited references should be independently checked before submission. Broader evidence indicates that app-based adherence interventions can be beneficial, but findings depend on the population, measurement method, and study quality (Pérez-Jover et al., 2019; Armitage et al., 2020). Educational media may also support iron-tablet adherence among adolescent girls (Septiana et al., 2025).

Possible Mechanisms and Nursing/Public Health Implications

The Puskesmas–UKS collaboration, nurse involvement, teacher oversight, and student supervisors may provide substantial adherence support irrespective of the application. Digital monitoring could still improve traceability and administrative workflows, but these process outcomes were not measured here. At the start of SiMerah implementation, Puskesmas personnel provided additional education on anemia and TTD; until attendance by group is verified,

education cannot be excluded as a co-intervention. Future iterations could capture nausea, vomiting, timing of symptoms, and referral needs using a clear clinical protocol, without conflating post-consumption vomiting with failure to swallow a scheduled dose. Sustained app engagement may depend on user-friendly design, reminders, and complementary personal support (Jakob et al., 2022). Future evaluation should include formal usability and quality assessment rather than inferring these outcomes from adherence records (Vera et al., 2019; Dawson et al., 2020).

Limitations

Strengths include a complete 186-row analytic recap, a concurrent comparison group, and integration into routine school health services. Limitations include nonrandomized group assignment, significant baseline imbalance, strong ceiling effects, an outcome restricted to 60/80/100% in this dataset, possible confounding from education and direct supervision, reliance on consumption documentation, and a single-school setting. Vomiting after documented consumption was reported as a field phenomenon but not systematically captured, so tablet retention, tolerability, and biological efficacy cannot be inferred. The adjusted regression is exploratory and does not resolve unmeasured confounding. Recruitment and exclusion counts outside the analytic recap were unavailable in the supplied manuscript and should be confirmed from enrollment records. Uncertainty about actual use of the digital functions may also affect intervention fidelity and generalizability.

Implications for Nursing Practice

School nurses and UKS teams can use documented adherence to identify students requiring follow-up and coordinate with Puskesmas personnel. In this study, digital monitoring did not demonstrate a statistically significant advantage in the primary change comparison. Whether SiMerah reduces staff workload, improves documentation accuracy, or increases usability remains untested and should be evaluated prospectively.

CONCLUSION

In this school-based quasi-experimental evaluation, recorded adherence did not improve significantly more with SiMerah than with conventional monitoring on the unadjusted pre–post change comparison. An exploratory baseline-adjusted post-test association favored the SiMerah group, but baseline imbalance and possible co-interventions preclude a firm causal effectiveness claim. The findings warrant cautious interpretation given high initial adherence, nonrandom allocation, and baseline imbalance. Implementation fidelity and tolerability outcomes require separate evaluation.

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AUTHOR CONTRIBUTIONS

Eva Agustina Yalestyarini: Conceptualization, Methodology, Project administration, Investigation, Supervision, Formal analysis, Writing – original draft, and Writing – review & editing. **Dedi Saifulah:** Methodology, Investigation, Data curation, Validation, and Writing – review & editing. **Joko Sutrisno:** Investigation, Data curation, Validation, and Writing – review & editing. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for their respective contributions to the research.

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CONFLICTS OF INTEREST

The authors declare no financial or commercial conflicts of interest related to this study. The SiMerah digital application was developed and evaluated as part of an academic research project funded through the Penelitian Dosen Pemula (PDP) grant scheme.

DECLARATION OF AI USE

During the preparation of this manuscript, the authors utilized ChatGPT (OpenAI) as an auxiliary tool for English language refinement, editorial clarity, and manuscript formatting. All AI-assisted outputs were subject to critical evaluation, verification, and revision by the authors. The authors retain full responsibility for the accuracy, originality, scientific integrity, and final content of the manuscript.

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