

The impact of integrated nutrition education program on iron supplement compliance: a quasi-experimental study in Cianjur, Indonesia

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ABSTRACT

Background: Weekly iron-folic acid (WIFA) supplementation programs are widely implemented to overcome anemia in adolescent girls. Their effectiveness is often constrained by low compliance, and evidence on the impact of nutrition education from rigorous studies remains limited.

Methods: This quasi-experimental study was conducted in four senior high schools in Cianjur from February to July 2025. Schools were non-randomly assigned to the control or intervention group, while participants were selected within each school using simple random sampling to reduce selection bias. In total, 112 adolescent girls were enrolled (control n=55, intervention n=57). Data on socioeconomic characteristics, knowledge, and attitudes were obtained through structured questionnaires. Compliance with weekly iron-folic acid (WIFA) supplementation was monitored using self-completed cards, and hemoglobin levels were measured from finger-prick samples. The intervention comprised TikTok-based nutrition education, supervised WIFA intake, and six months of compliance monitoring, followed by a 12-week post-intervention follow-up. Statistical analyses used a significance level of $p < 0.05$.

Results: At baseline, the intervention and control groups were largely comparable, with only non-significant differences in school type, sociodemographic characteristics, and knowledge ($p > 0.05$). Post-intervention, knowledge increased sig-

nificantly in the intervention group compared with the control group ($p < 0.001$), while attitudes remained high in both groups. During the intervention, compliance did not differ significantly between groups ($p > 0.05$), but follow-up showed higher compliance in the intervention group ($81.7 \pm 13.8\%$ vs. $68.8 \pm 12.4\%$; $p < 0.001$), suggesting a delayed effect of the intervention.

Conclusion: Knowledge of Nutrition education improved and sustained compliance to WIFA supplementation. However, its limited effect on attitudes. These findings support the integration of education and behavioral support into adolescent nutrition programs in areas with high stunting rates.

KEYWORDS

Adolescent health, digital intervention, health education.

INTRODUCTION

Stunting remains a persistent public health concern in Indonesia, with a prevalence of 19.8% among children under five in 2024¹. Despite sustained national efforts through both nutrition specific and nutrition sensitive interventions, progress has been slower than anticipated. Although Indonesia has rolled out a broad package of nutrition-specific measures alongside multi-sectoral nutrition-sensitive programs to curb stunting, existing evidence indicates that these initiatives have not yet delivered the rapid gains in child growth that policy-makers originally expected². One key strategy includes the weekly iron folic acid (WIFA) supplementation program targeting adolescent girls, particularly in districts with a high burden of stunting.

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This approach reflects the growing recognition that improving adolescent nutrition is essential for breaking the intergenerational cycle of undernutrition. The increasing policy emphasis on adolescence as a pivotal window for nutritional action underscores a wider shift in global health thinking, whereby strengthening adolescent diets and health is viewed as a prerequisite for interrupting the transmission of undernutrition from one generation to the next³. However, the limited achievement of national stunting reduction targets indicates that existing interventions require further strengthening, particularly in terms of effectiveness and behavioral uptake.

Adolescent girls are at heightened risk of iron deficiency anemia due to rapid growth, menstrual blood loss, and often inadequate dietary intake. The combined effects of increased iron requirements during the pubertal growth spurt, recurrent menstrual blood losses after menarche, and frequently suboptimal iron intake, adolescent girls constitute one of the populations most vulnerable to iron deficiency anemia⁴. This vulnerability is exacerbated in resource limited settings where access to diverse and nutrient rich foods is constrained. Anemia during adolescence has far reaching consequences, as it not only impairs physical capacity and cognitive performance but also increases the risk of adverse pregnancy outcomes later in life^{5,6}. Evidence suggests that maternal anemia is closely linked to intrauterine growth restriction and low birth weight, both of which are significant predictors of stunting. Therefore, improving iron status among adolescent girls is a critical preventive strategy to reduce future stunting prevalence.

Although the WIFA program has achieved relatively wide coverage, compliance to iron supplementation remains suboptimal. National data indicate a substantial gap between supplement distribution and actual consumption in accordance with recommended guidelines^{7,8}. This discrepancy is often driven by inadequate knowledge, negative attitudes, misconceptions about side effects, and low perceived benefits of supplementation⁹. Such behavioral barriers highlight the importance of addressing cognitive and psychosocial determinants alongside program delivery. Without improving knowledge and fostering positive attitudes, efforts to increase compliance are unlikely to achieve meaningful impact.

Nutrition education has emerged as a promising strategy to address these gaps by enhancing awareness, shaping attitudes, and promoting healthier practices related to iron supplementation¹⁰. Social media based education, particularly through platforms such as TikTok, provides a more effective alternative to conventional approaches by presenting concise, visually engaging, and easily accessible content that matches adolescents' daily media use, thereby enhancing attention and information retention. The increasing use of TikTok for health communication among young people further supports its potential as a relevant tool for delivering nutrition messages¹¹. In addition, social media facilitates repeated expo-

sure and interactive communication, both of which are important for reinforcing health-related behaviors. The inclusion of peer motivators also plays a critical role, as adolescents are more likely to accept and adopt messages delivered by individuals within their social group. Evidence suggests that peer-led strategies are more effective in influencing adolescent health behaviors than traditional teacher-centered methods¹². Furthermore, peer interaction in digital environments can strengthen motivation and shape health practices, including dietary behaviors¹³.

Overall, the combination of social media-based education and peer support offers a more engaging, scalable, and contextually appropriate approach, with greater potential to improve adherence to iron-folic acid supplementation among adolescent girls. However, evidence on its effectiveness in improving Compliance outcomes, particularly in high stunting areas, remains limited and context dependent. Rigorous evaluation using a quasi-experimental design is therefore essential to establish causal relationships between educational interventions and behavioral change. This study aims to assess the impact of a structured nutrition education intervention on knowledge, attitudes, and iron supplement compliance among adolescent girls living in high stunting areas. The findings are expected to provide evidence based insights to optimize adolescent nutrition programs and strengthen stunting prevention efforts.

METHOD

Study Design and Setting

The research adopted a quasi-experimental approach that included baseline and endline assessments for both the intervention and control groups. Measurements were carried out between February and July 2025 in four senior high schools in Cianjur, all situated in districts with a high burden of stunting. At the school level, allocation to the intervention or control condition was non-random, whereas individual students within each participating school were recruited using simple random sampling to limit selection bias. Full cluster randomization could not be implemented because of administrative and logistical limitations; therefore, the comparability of baseline characteristics across groups was carefully examined to reinforce the internal validity of the study

Study Participants and Sampling

Eligible participants were adolescent female high-school students who received WIFA supplementation, had no history of chronic illness, infectious disease, or hematologic disorder, were not consuming any comparable multivitamin-mineral preparations, were not pregnant, lived with their parents, and agreed to join the study.

The required number of subjects was obtained using a two-proportion sample size formula, to which an additional

20% was incorporated to account for potential attrition, resulting in a minimum target of 60 individuals in each group. At the end of data collection, 55 participants remained in the control arm and 57 in the intervention arm, in accordance with the sample size estimation for two proportions as previously described¹⁴:

$$N = \frac{(Z_{\alpha/2} \sqrt{2p(1-p)} + Z_{1-\beta} \sqrt{p_1(1-p_1)p_2(1-p_2)})^2}{(p_1 - p_2)^2}$$

$$n = \frac{(2.33 \sqrt{2(0.4)(1-0.4)} + 1.64 \sqrt{0.26(1-0.26)0.55(1-0.55)})^2}{(0.26 - 0.55)^2}$$

$n = 48.5$ plus 20% drop-out anticipation $n = 58.2$ or 60 respondents

Notes:

n : denotes the sample size.

$Z_{\alpha/2}$: represents the standard normal deviate corresponding to a 1% level of significance, with a value of 2.33.

$Z_{1-\beta}$: the standard normal deviate associated with 95% statistical power, with a value of 1.64.

p_1 : the proportion of the event of interest in the control group, defined as the percentage-point reduction in anemia prevalence in the control group (26%)¹⁵.

p_2 : the proportion of the event of interest in the intervention group, defined as the percentage-point reduction in anemia prevalence in the intervention group (54.7%)¹⁵.

Although compliance to WIFA supplementation was a key outcome assessed in this study, the sample size estimation was based on anemia as the primary clinical endpoint. This approach was adopted because compliance is considered an intermediate behavioral determinant that influences anemia outcomes over time, as widely reported in previous studies¹⁶. Therefore, the use of anemia-based sample size estimation was considered appropriate to capture both clinical and behavioral effects of the intervention.

Data Collection Tools and Technique

Data on participants' socio-economic characteristics and on their knowledge, attitudes, and practices regarding anemia and weekly iron-folic acid (WIFA) supplementation were obtained using a structured questionnaire that had previously undergone validity and reliability assessment. Compliance to WIFA intake was monitored through self-completed monitoring cards filled in by the participants. Hemoglobin concentration was determined from capillary blood collected by finger prick and analyzed with a HemoCue 201+ device, which provides rapid and reliable point-of-care hemoglobin measurements. Additional information on socio-economic conditions and on knowledge, attitudes, and practices related to anemia

and WIFA use was gathered through face-to-face interviews using a structured, pretested questionnaire administered by trained interviewers¹⁷.

The intervention was conducted over a six-month period and consisted of three main components: supervised WIFA consumption before class, the use of a compliance monitoring card, and structured nutrition education. In the intervention group, WIFA supplementation was administered before biology or physical education classes. After consuming the supplement, participants recorded their intake on the monitoring card. Each week, the monitoring cards were collected by a designated peer motivator, who then coordinated with the teacher to verify supplement consumption. Follow up monitoring was continued for three months after the intervention period.

The monitoring card also functioned as an educational tool, with its reverse side containing information on anemia and WIFA supplementation. Both the monitoring card and accompanying leaflet were updated monthly throughout the intervention. Peer motivators five students per school selected by teachers played a central role in facilitating the program. They participated in bi-weekly nutrition education sessions to enhance their understanding of anemia and WIFA supplementation and were responsible for disseminating educational materials to their peers.

The intervention group received audio-visual nutrition education delivered in the form of short 60 second animated videos ("reels"), distributed via popular social media platforms such as TikTok. These videos were played before WIFA consumption sessions and shared through class group chats to ensure accessibility. A total of 24 educational sessions were delivered, with monthly themes focusing on anemia and WIFA supplementation. Prior to implementation, the educational materials were reviewed and validated by experts in nutrition and education to ensure content accuracy, relevance, and appropriateness for the target population. In addition, teachers and peer motivators received targeted education to strengthen their knowledge and attitudes, enabling them to effectively support participants and respond to questions related to anemia and supplementation practices.

Data Analysis

Statistical procedures were undertaken to systematically describe and assess all study variables. Initially, descriptive analyses were performed by computing the mean, standard deviation, as well as minimum and maximum values for continuous data. For categorical variables, and continuous variables that were later grouped into categories, distributions were summarized using frequencies and proportions. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 26. Continuous variables were reported as mean $\pm$ standard deviation (SD),

whereas categorical variables were expressed as counts and percentages [n (%)]. Attitude scores were categorized into negative (<70), neutral ($70-80$), and positive (>80) based on percentage cut-off approaches commonly applied in KAP studies¹⁸.

Before conducting inferential tests, the distribution of continuous variables was examined using the Shapiro–Wilk test. Variables with p -values greater than 0.05 were regarded as approximately normally distributed and were analyzed with parametric procedures, whereas those with p -values at or below 0.05 were treated as non-normal and evaluated using non-parametric methods. For within-group comparisons, normally distributed data were analyzed using the paired-samples t -test, and when normality assumptions were violated, the Wilcoxon signed-rank test was applied¹⁹. Comparisons between independent groups with non-normal distributions were carried out using the Mann–Whitney U test²⁰. Statistical significance was determined using a two-sided p -value threshold of less than 0.05^{21,22}.

Ethical Statement

The study received ethical approval from the Research Ethics Committee of Universitas Muhammadiyah Semarang (Approval No: 705/KE/09/2024). Before the data collection began, each participant received a clear explanation of the study objectives, procedures, as well as the potential risks and benefits involved. All individuals provided their voluntary agreement to take part and completed a written informed consent form.

RESULTS

A total of 112 adolescent girls were enrolled in the study and evenly allocated to the control and intervention groups. Participants were drawn from both public and private schools. The proportion of students attending public schools was greater in the control group (72.7%) compared with the intervention group (57.9%), whereas the representation from private schools was higher in the intervention group (42.1%) than in the control group (27.3%). No statistically significant difference was observed in school type distribution between groups ($p=0.102$). However, a higher proportion of public school students was observed in the control group compared to the intervention group, which may still represent a potential source of residual confounding. The assessed characteristics included household size, weekly allowance, and mobile phone expenditure. The majority of participants in both groups resided in households with four or fewer members (90.9% in the control group and 93.0% in the intervention group). The average household size was comparable between groups, with 2.73 ± 1.18 individuals in the control group and 2.91 ± 0.91 in the intervention group. Previous evidence suggests that larger household size may reduce the proportion of expenditure allocated to food when

adjusted for per capita income²³. In terms of financial indicators, the control group reported a slightly higher mean weekly allowance (IDR 236,394 $\pm$ 158,517) than the intervention group (IDR 202,778 $\pm$ 139,827), with median values of IDR 200,000 and IDR 175,000, respectively, indicating relatively similar levels of economic support. A comparable pattern was observed for weekly mobile phone expenses, averaging IDR 18,642 $\pm$ 14,968 in the control group and IDR 21,320 $\pm$ 20,184 in the intervention group, with most participants in both groups spending between IDR 10,000 and 20,000 per week. These financial variables are relevant as proxies for household economic status and may influence adolescents' dietary practices and lifestyle behaviors²⁴. Overall, the findings indicate that the two groups were socio-demographically comparable at baseline, supporting the validity of subsequent comparisons. Further information is provided in Table 1.

Table 2 presents the distribution and scores of nutritional knowledge and attitude among adolescent school girls in the control and intervention groups at baseline and endline. Regarding nutritional knowledge, at baseline both groups were comparable, with the majority already classified in the high knowledge category (Control: 61.8%; Intervention: 64.9%). Median knowledge scores were not significantly different between groups (Control: 82.0, IQR 71.0–88.0; Intervention: 82.0, IQR 76.0–88.0; $p=0.836$), confirming baseline homogeneity between the two groups.

After the intervention, the proportion of participants categorized as having high knowledge rose substantially in the intervention group, increasing from 64.9% to 93.0%, whereas the control group exhibited only a slight change (from 61.8% to 67.3%). Within-group evaluation using the Wilcoxon signed-rank test indicated a significant improvement in knowledge scores among adolescents in the intervention group (median increased from 82.0 to 88.0; $p<0.001$), while scores in the control group showed no meaningful change (median remained at 82.0; $p=0.222$). At the endline assessment, the intervention group demonstrated markedly higher knowledge levels than the control group (median 88.0, IQR 85.0–94.0 versus 82.0, IQR 76.0–88.0; Mann–Whitney U test, $p=0.001$).

Attitudes toward nutrition among adolescent girls were assessed using statements that reflected negative, neutral, or positive perspectives on anemia and WIFA supplementation (Table 2). These attitudes covered understanding of anemia causes and consequences, prevention strategies, possible side effects, ways to manage those effects, and the benefits of IFA intake. At baseline nearly all respondents in both groups exhibited positive attitude scores (98.2% in both groups), with no significant difference in median scores (Control: 96.3, IQR 92.6–100.0; Intervention: 96.3, IQR 90.7–96.3; $p=0.581$), indicating no pre-existing difference between groups.

Table 1. Adolescent School Girls' Characteristics

Characteristics	Control		Intervention		p-value
	n	%	n	%	
School type					
- Public school	40	72.7	33	57.9	0.102
- Private school	15	27.3	24	42.1	
Number of family members (persons)					
- ≤ 4	50	90.9	53	93.0	0.125
- 5-6	4	7.3	4	7.0	
- >6	1	1.8	0	0.0	
Mean±SD	2.73±1.18		2.91±0.91		
Pocket money (IDR per week)					
- ≤ 70,000	1	1.8	2	3.5	0.364
- ≤ 70,000 – 140,000	19	34.5	22	38.6	
- > 140,000 – 210,000	13	23.6	20	35.1	
- > 210,000	22	40.0	13	22.8	
Mean±SD	236,394±158,517		202,778±139,827		
Median Min; Max	200,000 46,667; 1,050,000		175,000 14,000; 1,050,000		
Phone Bill (IDR per week)					
- ≤ 10,000	9	16.4	13	22.8	0.897
- ≤ 10,000 – 20,000	27	49.1	27	47.4	
- > 20,000 – 30,000	14	25.5	8	14.0	
- > 30,000	5	9.1	9	15.8	
Mean±SD	18,642±14,968		21,320±20,184		
Median Min; Max	14,000 0; 100,000		14,000 0; 98,000		

p-value based on Wilcoxon test. *significant if $p < 0.05$.

1 US\$=IDR 16,994.60.

At endline, the distribution and scores for nutritional attitude remained unchanged in both groups. No significant within-group differences were observed (Control: $p=0.247$; Intervention: $p=0.399$), and no significant between-group difference was found at endline (both groups: Median 96.3, IQR 92.6–100.0; $p=0.978$). The findings indicated no noticeable differences in attitudes toward anemia and IFA supplementation among the participants (Table 2).

In the control group, 70.9% of adolescents demonstrated high compliance ($>80\%$), whereas a smaller proportion of highly compliant participants was observed in the intervention group (54.4%, Table 3). By contrast, the intervention group contained a larger fraction of adolescents with moderate compliance (50–79%), accounting for 40.4% compared with 27.3% in the control group, and also a greater share with low compliance ($<50\%$). An independent t-test

Table 2. Nutritional Knowledge and Attitude of Adolescent School Girls at Baseline and Endline

Variable	Control (n = 55)	Intervention (n = 57)	Between-group p-value
	n (%)	n (%)	(Control vs Intervention)
A. Nutritional Knowledge			
Baseline			
Low (score <60)	3 (5.5)	1 (1.8)	
Moderate (score 60–80)	18 (32.7)	19 (33.3)	
High (score >80)	34 (61.8)	37 (64.9)	
Median (IQR)	82.0 (71.0 – 88.0)	82.0 (76.0 – 88.0)	0.836
Endline			
Low (score <60)	0 (0.0)	0 (0.0)	
Moderate (score 60–80)	18 (32.7)	4 (7.0)	
High (score >80)	37 (67.3)	53 (93.0)	
Median (IQR)	82.0 (76.0 – 88.0)	88.0 (85.0 – 94.0)	p<0.001**
Within-group p-value	0.222	p< 0.001***	
B. Nutritional Attitude			
Baseline			
Negative (score <70)	0 (0.0)	0 (0.0)	
Neutral (score 70–80)	1 (1.8)	1 (1.8)	
Positive (score >80)	54 (98.2)	56 (98.2)	
Median (IQR)	96.3 (92.6 – 100)	96.3 (90.7 – 96.3)	0.581
Endline			
Negative (score <70)	0 (0.0)	0 (0.0)	
Neutral (score 70–80)	1 (1.8)	1 (1.8)	
Positive (score >80)	54 (98.2)	56 (98.2)	
Median (IQR)	96.3 (92.6 – 100)	96.3 (92.6 – 100)	0.978
Within-group p-value	0.247	0.399	

The data was not distributed normally. Between-group comparisons were analyzed using the Mann–Whitney U test (Baseline: Control vs. Intervention; Endline: Control vs. Intervention), while within-group comparisons (Baseline vs. Endline within each group) were assessed using the Wilcoxon Signed-Rank test. Significant if *p<0.01; **p<0.001.

showed no significant difference in the total number of IFA tablets consumed between groups (p=0.88). The mean number of tablets taken was slightly higher in the control group (19.6±2.9) than in the intervention group (18.3±4.6), although this difference was not statistically significant. Overall compliance, expressed as percentage intake, was modestly higher in the control group (81.5±12.0%) than in

the intervention group (76.3±19.2%), but this difference also failed to reach statistical significance (p=0.089), indicating broadly comparable adherence levels across groups despite greater variability in the intervention arm

The follow-up assessment undertaken 12 weeks after the intervention showed a clear and persistent divergence in

Table 3. IFA Supplementation Compliance among Adolescent School Girls

Compliance	Control		Intervention		p-value
	n	%	n	%	
During the 24-Week Intervention Period					
Low (<50%)	1	1.8	3	5.3	
Moderate (50% -79%)	15	27.3	23	40.4	
High (>80%)	39	70.9	31	54.4	
Mean % compliance ± SD	81.5±12.0		76.3±19.2		0.089
Mean tablets consumed ± SD	19.6±2.9		18.3±4.6		0.088
During the 12-Week Follow-Up Period					
Low (<50%)	1	1.8	0	0.0	
Moderate (50% -79%)	46	83.6	20	35.1	
High (>80%)	8	14.5	37	64.9	
Mean % compliance ± SD	68.8±12.4		81.7±13.8		p<0.001*
Mean tablets consumed ± SD	8.3±1.5		9.8±1.7		p<0.001*

The data was distributed normally. p-value based on independent t-test. *significant if p<0.05.

compliance to IFA supplementation between the two study group (Table 3). In the control group, the majority of school girls (83.6%) were classified as having moderate compliance (50–79%), and only a small fraction (14.5%) achieved high compliance levels (>80%). In contrast, the intervention group displayed a markedly more favorable compliance profile, with 64.9% of participants reaching high compliance and none falling into the low-compliance category (<50%)

These findings were supported by the independent t-test, which showed a significant difference in the number of tablets consumed during the follow-up period. Participants in the intervention group took significantly more tablets (9.8 $\pm$ 1.7) than those in the control group (8.3 $\pm$ 1.5) (p<0.001). In addition, the average compliance rate was notably higher in the intervention group (81.7 $\pm$ 13.8%) compared to the control group (68.8 $\pm$ 12.4%), with this difference reaching statistical significance (p<0.001). Overall, these results indicate a marked improvement in sustained adherence after the intervention had ended.

DISCUSSION

This study demonstrated that a structured nutrition education intervention significantly improved knowledge related to anemia and WIFA supplementation among adolescent girls liv-

ing in high stunting areas. The findings showed a marked increase in knowledge scores in the intervention group compared to the control group, confirming the effectiveness of education based approaches in enhancing cognitive understanding. This is consistent with previous studies indicating that nutrition education plays a critical role in improving adolescents' knowledge, awareness of anemia prevention and dietary practices^{25,26}. Improved knowledge is an essential first step in behavior change, as it shapes individuals' ability to recognize health risks and adopt appropriate preventive actions.

Despite the significant improvement in knowledge, this study found no meaningful change in attitudes toward anemia and WIFA supplementation. Both groups already exhibited overwhelmingly positive attitudes at baseline, suggesting a possible ceiling effect that limited further measurable improvement. Similar findings have been reported in other studies where high baseline attitudes reduce the sensitivity of interventions to detect change. This indicates that while knowledge can be modified through educational exposure, attitudes may be more deeply rooted in prior beliefs, social norms, or cultural influences, requiring longer-term or more intensive interventions to achieve measurable shifts²⁷.

In terms of behavioral outcomes, the intervention did not produce a significant difference in WIFA supplementation

compliance during the 24-week intervention period. Compliance levels were relatively comparable between groups, with slightly higher mean compliance observed in the control group, although not statistically significant. This finding aligns with evidence suggesting that knowledge improvement alone is often insufficient to drive immediate behavioral change, particularly in the context of supplement compliance, which is influenced by multiple factors such as forgetfulness, perceived side effects, and environmental support²⁸. Behavioral change typically requires reinforcement mechanisms, sustained motivation, and supportive environments beyond information provision.

However, an important finding of this study is the significant improvement in compliance observed during the 12-week follow-up period in the intervention group. Participants exposed to the nutrition education intervention demonstrated higher compliance and greater tablet consumption compared to the control group. The pattern observed in this study suggests a delayed behavioral response to the intervention. Although no significant difference in compliance was detected during the intervention period, a substantial improvement emerged during the follow-up phase. This indicates that the effect of the intervention was not immediate but developed over time, possibly due to repeated exposure to educational content, reinforcement through peer support, and gradual habit formation. Behavioral change, particularly in compliance-related outcomes, often requires sustained cognitive processing and environmental support before being translated into consistent practice. Therefore, the findings should be interpreted as a temporal progression rather than isolated point differences²⁷. This highlights the importance of integrating behavioral support strategies within supplementation programs to achieve lasting impact²⁹.

This improvement in compliance during the follow-up phase may reflect the gradual development of habitual behavior shaped by repeated exposure to the intervention. During the intervention period, participants were still adapting to the new behavior and relied on external prompts such as supervision and structured activities, which may explain the absence of significant differences at that stage. In contrast, during the follow-up period, reduced supervision may have encouraged greater personal responsibility, allowing the behavior to become more self-regulated. Continuous engagement with supplementation routines, supported by monitoring tools and repeated educational messages, likely facilitated the transition from externally driven actions to more autonomous practices. According to habit formation theory, behaviors performed consistently within stable contexts can become automatic over time, reducing dependence on external cues. Furthermore, habit-based interventions have been shown to sustain health behaviors even after the active intervention phase ends. Evidence also indicates that stronger habit formation is as-

sociated with improved long-term adherence, as behaviors become less reliant on motivation and more driven by automatic processes³⁰. In this study, the routine of consuming WIFA before class, reinforcement from peer motivators, and repeated exposure to audio-visual content may have contributed to embedding this behavior into daily practice. These findings suggest that the higher compliance observed during follow-up reflects not only improved knowledge, but also the successful internalization of supplementation behavior into sustained habits.

Overall, this study highlights that nutrition education is effective in improving knowledge and can contribute to sustained behavioral change over time, particularly when combined with supportive mechanisms such as peer involvement and monitoring tools. However, its impact on attitudes and short-term compliance may be limited, and improvements in clinical outcomes such as anemia require more comprehensive and multifaceted approaches. These findings underscore the need to strengthen adolescent nutrition programs by integrating education with behavioral, environmental, and clinical strategies to effectively address anemia and contribute to stunting prevention in high-risk populations.

CONCLUSION

This study demonstrates that a structured nutrition education intervention can improve knowledge related to anemia and WIFA supplementation among adolescent girls in high stunting areas. While no significant changes were observed in attitudes and short-term compliance, the higher compliance during the follow-up period suggests a delayed yet sustained behavioral effect, indicating that consistent reinforcement is needed for behavior change. However, the findings should be interpreted cautiously due to several limitations, including non-random school-level allocation and the absence of multivariate analysis to account for potential confounding variables. Despite these limitations, the integration of social media-based education and peer support offers a practical and scalable approach. These findings suggest that policymakers, including health authorities and schools, should consider incorporating digital platforms and peer monitoring into iron supplementation programs, alongside stronger coordination and sustained behavioral strategies, to improve compliance and support long-term efforts in reducing anemia and preventing stunting.

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REFERENCES

1. Arief YS, Yunita FC, Efendi F, Aditya F, Murti K. Social and environmental determinants of childhood stunting in Indonesia : National cross-sectional study. *JMIR Pediatr Parent. JMIR Publications*; 8:1–11. DOI: 10.2196/68918
2. Andriani H, Arsyi M, Sutrisno A, Waits A, Rahmawati ND. Projecting the impact of a national strategy to accelerate stunting prevention in East Nusa Tenggara, Indonesia, using the lives saved tool Helen. *Narra J.* 2025;1(e1462). DOI: 10.52225/narra.v5i1.1462 wasting
3. Arlinghaus KR, Truong C, Johnston CA, Hernandez DC. An Intergenerational approach to break the cycle of malnutrition. *Curr Nutr Rep. Current Nutrition Reports*; 2018;7(4):259–67. DOI: 10.1007/s13668-018-0251-0
4. Söderman L, Stubbendorff A, Ladfors L V. Exploring the effect of menstrual loss and dietary habits on iron deficiency in teenagers : A cross-sectional study. *PLoS One.* 2025;20(12):1–14. DOI: 10.1371/journal.pone.0336688
5. More S, Shivkumar VB, Gangane N, Shende S. Effects of iron deficiency on cognitive function in school going adolescent females in rural area of Central India. *Hindawi Publ Corp.* 2013;1–5. DOI: 10.1155/2013/819136
6. Finkelstein JL, Kurpad A V, Bose B, Thomas T, Srinivasan K, Duggan C. Anaemia and iron deficiency in pregnancy and adverse perinatal outcomes in Southern India. *Eur J Clin Nutr.* 2023;74(1):112–25. DOI: 10.1038/s41430-019-0464-3
7. Alifiah E, Briawan D, Khomsan A, Dewi M, Ekayanti I, Mardewi, et al. Coverage and adherence of weekly iron folic acid supplementation among school going adolescent girls in Indonesia. *J Nutr Sci Vitaminol.* 2020;118–21. DOI: 10.3177/jnsv.66.S118.
8. Daba DD, Bidu KT, Heyi SK, Garoma D, Bieza Y. Compliance with weekly iron folic acid supplementation and associated factors among secondary school adolescent girls, in Jimma Arjo District, West Ethiopia, 2022: A mixed method cross-sectional Study. *World J Biol Pharm Heal Sci.* 2024;20(01):394–408. DOI: 10.30574/wjbpshs.2024.20.1.0800
9. Seminar A, Briawan D, Khomsan A, Dewi M, Ekayanti I, Mardewi, et al. Awareness about anaemia and weekly iron-folic acid supplementation (Wifas) among school-going adolescent girls and parents in east java and east nusa tenggara, indonesia. *J Nutr Sci Vitaminol (Tokyo).* 2020;66:S111–7. DOI: 10.3177/jnsv.66.S111
10. Wiafe MA, Apprey C, Annan RA. Nutrition education improves knowledge of iron and iron-rich food intake practices among young adolescents: A nonrandomized controlled trial. *Hindawi Int J Food Sci.* 2023;(1804763). DOI: 10.1155/2023/1804763
11. Basch CH, Hillyer GC, Jaime C. COVID-19 on TikTok: Harnessing an emerging social media platform to convey important public health messages. *Int J Adolesc Med Heal.* 2022;34(5):367–9. DOI: 10.1515/ijamh-2020-0111
12. Tang Y, Diao H, Jin F, Pu Y, Id HW. The effect of peer education based on adolescent health education on the resilience of children and adolescents: A cluster randomized controlled trial. *PLoS One.* 2022;1–18. DOI: 10.1371/journal.pone.0263012
13. Vaterlaus JM, Patten E V, Roche C, Young JA. Computers in human behavior getting healthy: The perceived influence of social media on young adult health behaviors. *Comput Human Behav. Elsevier Ltd*; 2022;45:151–7. DOI: 10.1016/j.chb.2014.12.013
14. Suresh KP. Sample size estimation and power analysis for clinical research studies. *J Hum Reprod Sci.* 2012;5(1). DOI: 10.4103/0974-1208.97779
15. Singh M. Assessment of weekly iron – folic acid supplementation with and without health education on anemia in adolescent girls: A comparative study. *Int J Prev Med.* 2020;11(203):66–9. DOI: 10.4103/ijpvm.IJPVM
16. Kumar N, Scott S, Menon P, Kannan S, Cunningham K, Tyagi P, et al. Pathways from women ' s group-based programs to nutrition change in South Asia: A conceptual framework and literature review. *Glob Food Sec.* 2018;17:172–85. DOI: 10.1016/j.gfs.2017.11.002
17. Yisak H, Ewunetei A. Knowledge, attitude, and practice with iron folic supplementation among antenatal care attendant women Debre Tabor, South Gondar Zone. *J Women's Heal Gynecol.* 2021;8. DOI: 10.17303/jwhg.2021.8.103
18. WHO. Guidelines for assessing nutrition-related knowledge, attitudes, and practices. Food and Agriculture Organization of the United Nations. 2014 p. 1–188.
19. Lee M, Park E. Comparative effectiveness of DistrACTION Cards and Buzzy for pain relief during intravenous infusion in preschool children in Korea: a quasi-randomized controlled trial. *Child Heal Nurs Res.* 2025;31(4):284–95. DOI: 10.4094/chnr.2025.026
20. Kwak SG, Park S. Normality Test in Clinical Research. *J Rheum Dis.* 2019;26(1):5–11. DOI: 10.4078/jrd.2019.26.1.5
21. Nicole MW, Balasubramaniam T, Nayak R, Barnett G A. An observational analysis of the trope "A p-value of < 0.05 was considered statistically significant" and other cut-and-paste statistical methods. *PLoS One.* 2022;17(3):1–15. DOI: 10.1371/journal.pone.0264360
22. Gros L, Schneider C, Meyer M, Korber J, Henchoz Y, Vaucher J, et al. Eligibility for lung cancer screening in Switzerland: A comparative analysis of three data sources from Lausanne and the Canton of Vaud. *Int J Public Health.* 2026;71(January):1–13. DOI: 10.3389/ijph.2026.1609104
23. Casado JM, Ignacio J, Labeaga JM, Alberto JM. Family size and food consumption: Exploring economies of scale with panel data. *J Fam Econ Issues.* Springer US; 2025;46(2):373–82. DOI: 10.1007/s10834-024-09971-x
24. Sakdiyah C, Handayani A. The influence of pocket money, lifestyle and self-control on student consumption behavior (study on management students at the University of Muhammadiyah Gresik). *Innov Res J.* 2018;131–8. DOI: 10.30587/innovation.v3i2.4169
25. Dwiriani CM, Rimbawan, Hardinsyah, Riyadi H, Martianto D. The effect of multi micronutrients supplementation and nutrition education on nutrition knowledge, nutrients adequacy ratio and iron

- status of young adolescent girls. *J Nutr Food*. 2011;6(3):171–7. DOI: 10.25182/jgp.2011.6.3.171-177
26. Khomsan A, Riyadi H, Ekawidyani KR, Dina RA, Nurhidayati VA, Prasetya G. A formative study of weekly iron-folic Acid (WIFA) supplementation for adolescent school girls in West Java Indonesia. 2025;45(1):438–44. DOI: 10.12873/451alikhomsan
 27. Vasquez-mamani LN, Cueva-calizaya LA, Gálvez-díaz NDC, Saintila J, Calizaya-milla YE. Effect of a nutrition education program on knowledge, attitudes, and dietary practices, anthropometry, and hemoglobin in Peruvian adolescents. *J Multidiscip Healthc*. 2025;1679–93. DOI: 10.2147/JMDH.S507564. eCollection 2025
 28. Sari DN, Hilmanto D, Sunjaya DK, Sari P. Community-based interventions to improve adolescent nutrition: A scoping review. *BMC Public Health*. 2025; DOI: 10.1186/s12889-025-25617-5
 29. Raut S, Kc D, Singh DR, Dhungana RR, Man P, Pradhan S, et al. Effect of nutrition education intervention on nutrition knowledge, attitude, and diet quality among school-going adolescents: A quasi-experimental study. *BMC Nutr*. 2024;1–10. DOI: 10.1186/s40795-024-00850-0
 30. Gardner B, Lally P, Rebar AL, Wit S De. What is Habit and How Can It Be Used To Change Real - World Behaviour? Narrowing The Theory - Reality Gap. Wiley. 2024;1–17. DOI: 10.1111/spc3.12975