

Pre–Post Changes in Anemia Knowledge and Attitudes Following HPM-Informed E-Booklet Education Among Adolescent GirlsWulan Novika Ambarsari¹, Ayu Apriyani¹, Rudi Karmi¹, Rahayu Savitri¹¹STIKes Budhi Luhur Cimahi, Indonesia**ABSTRACT**

Anemia is a reduction in hemoglobin concentration below an age-, sex-, and physiological-status-specific threshold and may result from nutritional deficiencies, blood loss, inflammation, inherited disorders, or other causes. Menstruating adolescent girls are a priority population for prevention and educational interventions. This study aimed to assess immediate pre-post changes in knowledge and attitudes toward anemia following an e-booklet educational intervention informed by Pender's Health Promotion Model (HPM). A quantitative one-group pretest-posttest study was conducted among 77 adolescent girls at SMK Pasundan 3 Cimahi. Participants were selected from a population of 327 students using proportionate stratified random sampling. Recruitment and consent/assent were followed by a pretest assessment, standardized e-booklet education, and an immediate posttest. Knowledge was categorized as good, fair, or poor, while attitudes were categorized as positive or negative. Data were analyzed using the Marginal Homogeneity and McNemar tests. The proportion of participants with good knowledge increased from 16.9% to 79.2% (absolute change: +62.3 percentage points), while poor knowledge decreased from 58.4% to 2.6% ($p < 0.001$). Positive attitudes increased from 54.5% to 76.6% (absolute change: +22.1 percentage points; $p = 0.005$). Knowledge and attitude categories were more favorable immediately after the e-booklet intervention. Because the study lacked a comparison group and assessed outcomes only immediately after the intervention, controlled studies with validated continuous measures and longer follow-up are needed to establish the effectiveness and sustainability of the observed changes.

Keywords: adolescent girls, anemia, attitudes, e-booklet, health education, knowledge

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INTRODUCTION

Anemia is defined by a hemoglobin concentration below a population-specific cut-off rather than by iron deficiency alone. Under the 2024 World Health Organization guideline, the cut-off for non-pregnant girls aged 12–14 years and non-pregnant women aged 15–65 years is <120 g/L at sea level, with adjustment where required for altitude and smoking. Iron deficiency is an important cause, but anemia may also reflect other micronutrient deficiencies, menstrual or other blood loss,

infection, inflammation, hemoglobin disorders, or chronic disease (World Health Organization, 2024). Menstruating adolescent girls are particularly vulnerable because iron requirements increase during growth and menstrual blood loss can further reduce iron stores.

Anemia remains a substantial public health problem. The World Health Organization estimated that approximately 30% of non-pregnant women aged 15–49 years were anemic in 2019, with Southeast Asia among the most affected regions (World Health Organization, 2025). In Indonesia, the 2018 Basic Health Research reported anemia in 26.8% of people aged 5–14 years and 32.0% of those aged 15–24 years (Ministry of Health of the Republic of Indonesia, 2022). Local routine screening data from the Cimahi City Health Office reported a prevalence of 73.03% across the senior high school screening population in the Melong Asih Public Health Center area, whereas the school-specific prevalence at SMK Pasundan 3 Cimahi was 30.91%. These figures use different denominators: the first summarizes the health center service-area screening cohort, while the second refers specifically to students screened at SMK Pasundan 3 Cimahi (Cimahi City Health Office, 2023).

Adolescent anemia can be associated with fatigue, reduced concentration, lower physical capacity, and impaired school participation. Preventive behavior includes consuming a diverse iron-rich diet, combining plant-based iron sources with vitamin C, avoiding inhibitors around meals when possible, and following national guidance for iron-folic acid supplementation. Knowledge alone does not guarantee behavior change, but accessible health education can strengthen risk awareness, correct misconceptions, and support more favorable attitudes toward prevention.

Digital booklets are practical for school-based education because text, illustrations, and action-oriented messages can be delivered through commonly used devices and revisited after the session. Previous studies have reported improvements in anemia-related knowledge or attitudes after booklet or e-booklet education (Imanuna, 2022; Nikmah *et al.*, 2022; Puspadiina & Kurniawati, 2023; Sheladjiq & Yulianti, 2023; Paramita *et al.*, 2024). However, most studies have treated the booklet primarily as an information medium and have not clearly linked its educational components to a nursing health promotion framework.

The innovation of the present study was the explicit use of Pender's Health Promotion Model as an organizing framework for the e-booklet. The educational messages were structured around perceived benefits of anemia prevention, perceived barriers such as concerns about iron-tablet side effects, self-efficacy for selecting iron-rich foods and following supplementation guidance, interpersonal support from family, peers, schools, and health workers, and commitment to practical preventive actions. These HPM constructs were used to organize the intervention, while knowledge and attitudes were evaluated as proximal educational outcomes; the constructs themselves were not analyzed as separate variables (Pender *et al.*, 2015; Rahmawati & Rohimah, 2023).

A preliminary assessment at SMK Pasundan 3 Cimahi indicated that students had not received structured school-based education on anemia. Interviews with 10 students suggested limited understanding and concerns regarding iron supplementation. Accordingly, this study assessed changes in anemia-related knowledge and attitudes from pretest to the immediate posttest following HPM-informed e-booklet education among adolescent girls at SMK Pasundan 3 Cimahi.

METHODS

This quantitative pre-experimental study used a one-group pretest-posttest design. The study was conducted at SMK Pasundan 3 Cimahi, Cimahi City, West Java, Indonesia. Because all participants received the intervention and no comparison group was included, the design was intended to assess within-participant change rather than establish a definitive causal effect.

The source population comprised 327 female students. The original study determined a target sample of 77 participants using the Slovin formula with proportionate stratified random sampling. Students were allocated proportionately across school strata and selected randomly from the sampling frame. Eligible participants were enrolled female students who were present during data collection and provided the required consent or assent. Questionnaires without paired pretest and posttest data were excluded from the paired analysis. All 77 participants completed both assessments, and no missing paired outcome data were reported. A sensitivity calculation indicates that a paired sample of 77 provides approximately 80% power at a two-sided alpha of 0.05 to detect a standardized within-participant effect of approximately 0.32. The use of the Slovin formula rather than an a priori effect-based sample size calculation is acknowledged as a methodological limitation.

The research team developed a digital e-booklet informed by Pender's Health Promotion Model (HPM) and previous anemia education literature. Core content addressed the definition and causes of anemia, signs and consequences, menstrual and dietary risk factors, iron-rich food choices, iron-folic acid supplementation, strategies for managing commonly perceived barriers, sources of social support, and simple prevention commitments. The same standardized material and instructions were provided to all participants. The intervention was delivered in a supervised school-based educational session, and the e-booklet remained accessible to participants for review. The posttest was administered immediately after the educational activity. The HPM-to-intervention mapping is shown in Table 1.

Table 1. Operationalization of Pender's Health Promotion Model in the e-booklet

HPM construct	E-booklet component	Expected proximal response
Prior related behavior and personal factors	Reflection on dietary habits, menstrual risk, prior information, and iron-tablet use	Recognition of personal risk and learning needs
Perceived benefits	Benefits of iron-rich foods, supplementation, and early prevention	More favorable beliefs about prevention
Perceived barriers	Common concerns and practical responses, including managing anticipated side effects and access barriers	Reduced perceived obstacles
Perceived self-efficacy	Simple food-selection steps, supplementation guidance, and prevention checklist	Greater confidence in preventive action
Interpersonal influences	Encouragement to seek support from family, peers, teachers, and health workers	Stronger perceived social support
Commitment to action	Short action points for diet, supplementation, and seeking advice	Intention to undertake preventive behavior

The study sequence was: identification of the sampling frame → random selection within strata → school authorization and participant consent/assent → pretest → standardized HPM-informed e-booklet education → immediate posttest → data checking and paired statistical analysis.

A structured questionnaire was administered at both time points. Knowledge was assessed using multiple-choice items and summarized into good, fair, and poor categories. Attitudes were assessed using Likert-type items and categorized as positive or negative. The same instruments and scoring procedures were used at pretest and posttest. The source manuscript did not provide the full item count, category cutoffs, instrument development history, or psychometric coefficients; therefore, these specifications should be verified against the original questionnaire and validation

records before submission. Reporting these details is essential for reproducibility and interpretation.

Frequencies and percentages summarized age and outcome categories. The Marginal Homogeneity test was used for the paired three-category knowledge outcome because it evaluates whether the marginal distribution changes across two related measurements. McNemar's test was used for the paired binary attitude outcome and is based on discordant pre-post pairs. Statistical significance was set at $p < 0.05$. Results are presented as $p < 0.001$ when the software output was 0.000. Absolute percentage-point changes are reported to show the magnitude of change. The null hypothesis was considered not rejected when $p \geq 0.05$. Exact paired transition counts, test statistics, degrees of freedom, confidence intervals, and effect size measures should be generated from the original participant-level dataset before journal submission because they cannot be reconstructed uniquely from marginal totals alone.

Ethical approval was granted by the Health Research Ethics Committee of STIKes Budi Luhur Cimahi (No. 74/D/KEPK-STIKes/III/2025), and authorization was obtained from the school. Participation was voluntary. Students younger than 18 years provided assent with parental or guardian permission, whereas participants aged 18–19 years provided their own informed consent. Participants could decline or withdraw without academic consequences. Questionnaires were coded, identifying information was not included in the analytical dataset, and access to the data was restricted to the research team.

RESULTS

All 77 selected participants completed both the pretest and posttest. Participants were 15–19 years old, and the largest age group was 17 years (39.0%). Religion was removed from the descriptive table because it was not included in the study objectives, theoretical framework, or statistical analysis.

Table 2. Age distribution of participants (n = 77)

Age (years)	n	%
15	6	7.8
16	26	33.8
17	30	39.0
18	14	18.2
19	1	1.3
Total	77	100.0

Table 3. Knowledge and attitude categories before and immediately after the e-booklet education (n = 77)

Outcome	Category	Pretest, n (%)	Posttest, n (%)	Absolute change (percentage points)
Knowledge	Good	13 (16.9)	61 (79.2)	+62.3
	Fair	19 (24.7)	14 (18.2)	-6.5
	Poor	45 (58.4)	2 (2.6)	-55.8
Attitude	Positive	42 (54.5)	59 (76.6)	+22.1
	Negative	35 (45.5)	18 (23.4)	-22.1

Table 4. Paired tests of pre-post change

Outcome	Paired test	Reported p-value	Magnitude of observed change	Interpretation
Knowledge	Marginal Homogeneity	<0.001	Good: +62.3 percentage points; Poor: -55.8 percentage points	The marginal distribution was more favorable at the immediate posttest.
Attitude	McNemar	0.005	Positive: +22.1 percentage points	The proportion with a positive attitude was higher at the immediate posttest.

Note: The participant-level 3 x 3 knowledge transition table and 2 x 2 attitude transition table must be verified and inserted from the original dataset; marginal totals do not uniquely identify all within-participant transitions.

DISCUSSION

The study showed a substantial immediate shift in knowledge categories after the e-booklet session. The proportion of participants categorized as having good knowledge increased by 62.3 percentage points, while the poor knowledge category decreased by 55.8 percentage points. Similar improvements following booklet- or e-booklet-based education have been reported among Indonesian adolescents (Nikmah *et al.*, 2022; Puspadiina & Kurniawati, 2023; Sheladjiq & Yulianti, 2023; Paramita *et al.*, 2024). The current findings extend this literature by describing the educational material within an HPM-informed framework rather than treating the booklet solely as a vehicle for factual information.

Several plausible mechanisms may explain the observed pattern. Concise text and illustrations may support comprehension and recall, while digital access may allow participants to review the material at their own pace. The HPM-informed content also linked information to perceived benefits, perceived barriers, self-efficacy, social support, and practical actions. These mechanisms remain theoretical interpretations because HPM constructs, participant engagement, reading time, and intervention fidelity were not measured directly. The immediate posttest may also have been influenced by repeated testing and short-term recall.

Positive attitudes increased by 22.1 percentage points. This finding is consistent with previous booklet-based educational studies reporting more favorable attitudes following educational interventions (Imanuna, 2022; M *et al.*, 2024; Paramita *et al.*, 2024). The increase is practically relevant because more favorable attitudes may support readiness to adopt preventive behaviors. Nevertheless, this study did not examine whether knowledge mediated attitude

change, nor did it measure subsequent iron-folic acid supplementation adherence, dietary behavior, hemoglobin concentration, or anemia status. The attitude findings should therefore be interpreted as an immediate change in questionnaire categories rather than evidence of sustained behavioral change.

The findings should not be attributed exclusively to the e-booklet or the HPM framework. Without a comparison group, alternative explanations include testing effects, history, maturation, regression to the mean, social desirability bias, and the Hawthorne effect. Although the substantial improvement in knowledge categories is encouraging, statistical significance alone does not demonstrate educational effectiveness or long-term sustainability. Future studies should compare the intervention with standard education or another active educational medium and evaluate whether improvements are maintained after several weeks or months.

First, the one-group pretest-posttest design limits causal inference. Second, participants were recruited from a single school, limiting the generalizability of the findings. Third, the immediate posttest did not allow assessment of knowledge or attitude retention over time. Fourth, categorizing questionnaire scores may reduce information and obscure smaller individual changes. Fifth, complete psychometric information and intervention-fidelity data were not available in the source manuscript. Sixth, participant-level transition tables and effect-size estimates require verification using the original dataset. Finally, no behavioral or hematological outcomes were measured.

CONCLUSION

Among 77 adolescent girls at one vocational school, knowledge and attitude categories were more favorable immediately after HPM-informed e-booklet education. These findings support further evaluation of digitally delivered anemia education; however, the uncontrolled study design and immediate follow-up do not establish effectiveness or long-term sustainability. Controlled, multischool studies using validated continuous outcome measures, longer follow-up, and behavioral and hemoglobin outcomes are needed.

RECOMMENDATION

Schools and community health centers may consider piloting HPM-informed e-booklet-based anemia education as part of existing adolescent health programs while evaluating its feasibility, participant engagement, and knowledge retention. Future research should use controlled study designs, report complete evidence of instrument validity and reliability, preserve continuous outcome measures where appropriate, document intervention fidelity, include participant-level paired transition tables, recruit participants from multiple schools, and evaluate iron-folic acid supplementation adherence, dietary practices, and hemoglobin outcomes over longer follow-up periods.

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