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A Web-Based Educational Model for Anemia Prevention in Pregnant Women

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ABSTRACT

Aims This study aimed to develop the American national institutes for social advancement education model to support anemia prevention through a digital approach.
Materials & Methods This quantitative research employed a research and development design that included model development, expert validation, one-on-one testing, small-group testing, and effectiveness testing using a pre-post-test design. Participants included pregnant women in Merangin District, Jambi Province selected using purposive sampling. Validated and reliable questionnaires measured knowledge and attitudes. Data were analyzed using the Wilcoxon and Mann-Whitney U tests.
Findings The American national institutes for social advancement model was considered feasible based on assessments of navigation, language clarity, content completeness, visual appeal, and technical performance. Effectiveness testing showed a significant improvement in mothers' knowledge after the intervention ($p<0.001$) and a significant improvement in attitudes ($p<0.001$). Between-group comparisons indicated that the intervention group had significantly higher post-test knowledge than the control group ($p<0.001$), although the differences in attitudes were not statistically significant ($p=0.252$).
Conclusion The American national institutes for social advancement model is effective in improving knowledge and enhancing attitudes related to anemia prevention among pregnant women.

Keywords Anemia; Attitude; Health Education; Pregnant Women; Prevention

CITATION LINKS

[1] Global prevalence of anemia in pregnant women: A comprehensive systematic review ... [2] Iron deficiency anemia among women of reproductive age, an important public health ... [3] "Srikandi Health": Development of a progressive web apps based health information system as a solution for ease of monitoring and ... [4] Efficacy of a personalized mHealth app in improving micronutrient supplement use among pregnant women in Karachi, Pakistan ... [5] Guideline: Daily iron and folic acid supplementation ... [6] Main results of RISKESDAS ... [7] Effectiveness of educational media in preventing anemia among adolescent ... [8] Screening and education application tool for prevention of anemia complications among pregnant ... [9] 2023 Riskesdas ... [10] Changes in knowledge and attitudes of adolescent girls towards anemia prevention through Android-based ... [11] Using of health belief model to promote preventive behaviors against iron deficiency ... [12] The effectiveness of a theory-based intervention program for pregnant women with ... [13] Effectiveness of daily educational message on pregnancy anemia prevention behavior and knowledge ... [14] The effect of android-based pregnancy education and care on improving ... [15] Effectiveness of android-based educational media on knowledge, dietary intake and hemoglobin levels for ... [16] Community-based analysis of anemia risk factors in pregnant ... [17] Time for a change: Putting the transtheoretical (stages of change) ... [18] The transtheoretical model and ... [19] Effect of educational program based on theory of planned behavior on promoting nutritional behaviors preventing Anemia in a sample ... [20] Utilizing health belief model to enhance the preventive behavior against iron-deficiency anemia ... [21] Does tailoring matter? Meta-analytic review of tailored print health ... [22] The impact of an android application on compliance with iron ... [23] Education and reminder software for strengthening anemia prevention ... [24] Development of a monitoring and guidance Android application ... [25] Feel supported and not alone: A qualitative study of supports needed by pregnant ... [26] Development of "Tamia" (Antisipative of Anemia) Android base to improve knowledge and practice of anemia prevention among female... [27] A smartphone-based health behavioral intervention for pregnant women ...

Introduction

Anemia in pregnant women is one of the most widely recognized public health problems globally, posing serious risks to both the mother and the fetus. Conceptually, anemia is a condition characterized by hemoglobin levels falling below normal, which results in a reduced oxygen-carrying capacity of the blood [1, 2]. This condition is associated with inadequate nutritional intake, infections, socioeconomic constraints, and various biological and environmental factors. During pregnancy, iron requirements increase significantly due to fetal growth, changes in plasma volume, and the body's preparation for childbirth. Therefore, maternal health perspectives emphasize that adequate nutrition and preventive behaviors are fundamental pillars for maintaining the physiological balance of pregnant women [3].

Overall, anemia prevention among pregnant women has become a major focus of both global and national health policies [4]. The World Health Organization (WHO) recommends iron-folic acid supplementation and nutritional education as the primary strategies for reducing the prevalence of anemia in this population [5]. In Indonesia, these recommendations are implemented through the provision of a minimum of 90 iron tablets during pregnancy, education via the Maternal and Child Health (MCH) handbook, and regular monitoring during antenatal care visits [6]. However, the effectiveness of these efforts largely depends on maternal health behaviors, including adherence to iron tablet consumption, understanding of anemia, and the ability to adopt a balanced diet. Thus, health promotion and behavior change frameworks play an essential role in reducing anemia among pregnant women [7, 8].

Field observations indicate that despite the implementation of various prevention programs, the prevalence of anemia in pregnant women remains high. The 2018 National Basic Health Research (Riskesdas) reported a significant increase in anemia prevalence from 37.1% to 48.9% within five years, indicating that nearly half of pregnant women in Indonesia experience anemia. In Jambi Province, particularly in Merangin District, anemia remains a concern despite high coverage of iron tablet distribution [9]. This situation reflects a discrepancy between intervention efforts and their expected outcomes, suggesting that the challenge lies not only in program availability but also in implementation and acceptance by the target population [10].

A clear gap is evident in the fact that pregnant women have access to iron tablets and educational materials via the MCH book, yet compliance and the adoption of preventive behaviors remain low. Issues such as discomfort from side effects, boredom, forgetfulness, lack of family support, and inaccurate perceptions of anemia risk hinder behavior change. Additionally, non-interactive information sources limit the absorption of health education. Thus, a gap exists between the educational interventions provided and the actual behaviors practiced in daily life.

A research gap persists, as most previous interventions for anemia prevention rely solely on non-electronic educational media, such as booklets, direct counseling, or simple applications that provide only one-way information. Existing Android-based applications often lack interactive features, integration with health services, monitoring systems for iron tablet consumption, and family involvement as behavioral reinforcers. To date, no studies in Indonesia have developed a comprehensive web-based educational model that integrates promotive, preventive, curative, diagnostic, and monitoring features into a single platform. This gap highlights the need for more effective digital interventions focused on behavior change.

The urgency of this study is underscored by the fact that anemia during pregnancy increases the risk of complications, preterm birth, impaired fetal development, and maternal and neonatal mortality. Meanwhile, the rapid advancement of digital technology and increasing smartphone access provide an ideal opportunity to introduce an app-based educational model that can be accessed anytime and supports gradual behavior change. Technology-based interventions are considered more flexible, personalized, and capable of delivering reminders and monitoring mechanisms that conventional education cannot provide. Therefore, the development of an application-based educational model is essential within maternal health services [11-13].

The novelty of this research lies in the development of the American national institutes for social advancement (ANISA) education model (anticipatory education for anemia-aware pregnant women), which is a comprehensive web-based application that integrates promotive, preventive, curative, diagnostic, and monitoring/feedback features. This model not only provides educational materials through text, images, and videos, but also includes reminders for iron tablet consumption, daily nutritional monitoring menus, self-assessment diagnostic tools, virtual consultations with health workers, and family involvement to strengthen maternal health behaviors. Such innovation has not been documented in previous studies, making it a potential breakthrough in technology-based anemia prevention.

The aim of this study was to develop and evaluate the ANISA educational model as a digital intervention for anemia prevention in pregnant women. Specifically, the study sought to assess the model's feasibility, identify its developmental stages, and examine its impact on improving pregnant women's knowledge and attitudes regarding anemia prevention. Using a research and development approach, this model is

expected to serve as both an educational tool and an effective behavioral monitoring system.

The benefits of this research include providing health institutions with evidence-based guidance for designing more effective anemia prevention programs, offering innovative learning media for health education, and serving as a reference for researchers developing technology-based models for other health issues. For pregnant women and their families, this model is expected to enhance health literacy, support adherence to iron tablet consumption, and reinforce independent anemia-prevention behaviors. Thus, the study has the potential to contribute directly to reducing the prevalence of anemia among pregnant women, especially in high-risk areas such as Merangin District.

Materials and Methods

This quantitative study employed a research and development design that combined model development and intervention effectiveness testing, and was conducted in primary healthcare facilities in Merangin District, Jambi Province in 2025.

The statistical population included all pregnant women attending antenatal care (ANC) visits during the second and third trimesters at selected community health centers (Puskesmas) in Merangin District, with data collection and implementation of the intervention carried out from March to July 2025. The sample was drawn from this population using purposive sampling, selecting respondents based on their suitability with the study criteria. The inclusion criteria consisted of pregnant women aged 18-45 years, in their second or third trimester, capable of reading and writing, owning an Android smartphone with basic internet access, and willing to participate in the study. The exclusion criteria included pregnant women with severe medical complications, such as severe preeclampsia, obstetric bleeding, severe chronic diseases, or those unable to complete the digital education program. The sample size in this study was determined based on the calculation required for comparing two independent groups, namely the intervention group and the control group. The calculation considered a 95% confidence level (α=0.05) and a statistical power of 80% (β=0.20), as well as the expected difference in mean knowledge and attitude scores between the two groups after the intervention. Assuming a moderate effect size (effect size=0.5), the minimum required sample size was 45 participants in each group.

To account for potential participant attrition (dropout) during the study, an additional 10% was added, resulting in a final sample size of 50 participants per group. Therefore, the total sample size in this study comprised 100 pregnant women, with 50 participants in the intervention group and 50 in the control group.

The research design utilized a pre-post-test method without a control group, in which respondents were assessed before and after using the ANISA educational model to determine changes in knowledge and attitudes related to anemia prevention among pregnant women. The research stages followed the model development flow, expert validation, limited trials, and effectiveness testing, providing a comprehensive overview of the feasibility and impact of the educational model developed. The selected location is characterized by a high prevalence of anemia among pregnant women and increased access to digital technology. The research was carried out over six months, covering model development, data collection, and final analysis of the intervention outcomes.

The analyze phase involved a needs assessment to identify key problems, field conditions, user characteristics, and theoretical foundations for the digital educational model. Data were collected through interviews with pregnant women, healthcare workers, and program managers to explore barriers to anemia prevention and the feasibility of a digital intervention. Contextual analysis examined technological readiness, cultural influences, and organizational support. A literature review identified behavioral theories, including the health belief model, prevention theory, diffusion of innovation, PRECEDE-PROCEED, and the transtheoretical model (TTM), that guided the conceptual framework of the ANISA model.

The design phase included collaboration among programmers, expert validators, monitoring administrators, and pregnant women as end users. The team created the initial prototype of the ANISA application, which consisted of five integrated features: promotive, preventive, curative, diagnostic, and monitoring. Wireframes, user interface layouts, and user flow diagrams were developed and refined to ensure simple navigation and alignment with user needs before prototype construction.

The development phase consisted of expert validation, one-to-one testing, small group testing, and field trials. Experts in maternal health, nutrition, public health, and technology reviewed the model for content accuracy, theoretical alignment, and clarity. One-to-one testing with four pregnant women assessed usability and visual elements, leading to improvements in interface and content presentation. Subsequent small group testing and field trials evaluated real-world feasibility and identified remaining technical and instructional issues. These processes ensured content integrity, interface feasibility, and technical functionality.

Implementation followed the TTM, guiding pregnant women through the stages of pre-contemplation, contemplation, action, and maintenance. Participants utilized the ANISA features to access educational materials, preventive guidance, reminder tools, and diagnostic assessments. Health workers monitored

progress through the Monitoring feature and provided necessary feedback or virtual support, ensuring that the model functioned as both an educational and behavioral support system.

The ANISA model comprised five integrated features. The promotive feature provided educational videos, infographics, and written materials on anemia. The preventive feature contained nutrition guidelines, booklets, and daily adherence checklists. The curative feature offered a 90-day iron tablet reminder alarm and digital certificates. The diagnostic feature enabled users to complete self-screening questions or input laboratory data. The monitoring feature facilitated communication and feedback between pregnant women and healthcare workers to support continuous behavioral reinforcement.

Knowledge was measured using a researcher-made multiple-choice questionnaire containing validated and reliable items that assessed understanding of anemia definitions, causes, signs and symptoms, impacts, and preventive measures. Knowledge scores were calculated based on the number of correct answers and categorized into good, fair, and poor according to established criteria. Attitudes were measured using a 1-4 Likert scale consisting of positive and negative statements related to anemia prevention behaviors, iron tablet consumption, dietary patterns, and utilization of health services. The ANISA application use was assessed based on user engagement with educational features, iron tablet reminder alarms, nutritional monitoring menus, and interactions with healthcare workers through the platform.

The questionnaires used were researcher-made developed with reference to relevant previously published questionnaires and adapted to the local context and the objectives of the ANISA educational model development. Content validity was assessed through expert judgment by specialists in maternal and child health, nutrition, and public health. Reliability testing was conducted during a pilot study, which demonstrated that both the knowledge and attitude questionnaires achieved acceptable reliability coefficients (Cronbach's alpha≥0.70).

All participants signed an informed consent form prior to data collection. Data collection was conducted in two phases: an initial assessment (pre-test) before respondents used the ANISA application and a final assessment (post-test) after the intervention period of 4-8 weeks. The research tools consisted of online questionnaires integrated into the application, as well as manual questionnaires when needed to ensure complete data. The researchers also monitored respondent engagement with the application, including the frequency of accessing educational features and adherence to iron tablet reminder alarms. All collected data were compiled in electronic spreadsheets and later analyzed statistically.

Data analysis was conducted using SPSS 23. To assess the effectiveness of the educational model in improving knowledge and attitudes, the Wilcoxon signed-rank test was used, as the data were non-normally distributed according to the Shapiro-Wilk test. Meanwhile, comparisons between the two groups were performed using the Mann-Whitney U test. All statistical tests utilized a significance level of $\alpha=0.05$.

Findings

The Wilcoxon test indicated a statistically significant increase in knowledge score of the intervention group after the intervention ($p<0.001$). There was also a significant improvement in the control group ($p<0.001$). The between-group comparison showed that the intervention group had a significantly higher post-test knowledge score than the control group ($p<0.001$).

The Wilcoxon test indicated a statistically significant increase in attitude score in the intervention group after the intervention ($p<0.001$). There was also a significant improvement in the control group ($p<0.001$). However, the Mann-Whitney test revealed no statistically significant difference in post-test attitude scores between the groups ($p=0.252$; Table 1).

Table 1. Median (IQR) knowledge and attitude scores in the intervention and control groups

Parameter	Group	Pre-test	Post-test	p-Value (pairwise comparison)
Knowledge	Intervention	18 (17-19)	25 (24-26)	<0.001
	Control	18 (17-18)	20 (19-21)	-
Attitude	Intervention	72 (70-73)	75 (74-77)	0.252
	Control	72 (71-73)	73 (72-74)	-

p-Value<0.001 for all.

Discussion

This study aimed to develop the ANISA education model to support anemia prevention through a digital approach. All research objectives were successfully achieved, particularly in developing and testing the effectiveness of the ANISA educational model as a digital education media for anemia prevention among pregnant women. This model was deemed feasible based on the one-to-one and small-group evaluation stages, which demonstrated high levels of usability, content clarity, visual appeal, and technical performance. Furthermore, there was a significant increase in both parameters following the intervention. All respondents in the intervention group experienced a significant increase in knowledge and attitude, indicating that application-

based digital interventions are effective in influencing pregnant women's behavior toward anemia prevention.

The ANISA application not only improved pregnant women's knowledge but also enhanced their attitudes regarding anemia prevention, although the degree of improvement in attitude was lower than that in knowledge. This is evident from the 17 respondents with no change in attitude scores (ties) in the Wilcoxon results, though the overall effect remained positive. The between-group comparison further supports these findings, revealing that post-test knowledge scores in the intervention group were significantly higher than those in the control group. However, for attitude, while the intervention group had a higher median score, the difference was not statistically significant. Thus, attitude change requires a longer process and is influenced by internal and external factors, such as pregnancy experience, family support, cultural beliefs, and risk perception.

Compared to previous studies, these findings align with evidence demonstrating the effectiveness of digital education media in improving health knowledge and behavior. Setyaningrum *et al.* [14] found that an Android-based educational application significantly improves knowledge after four weeks of use. Similarly, Magfirah *et al.* [15] report that a combination of a booklet and a digital application produces better outcomes than conventional education alone. However, the present study contributed novel insights by showing that a web-based educational model with interactive features—such as reminder alarms, digital certificates, diagnostic tools, and self-monitoring options—had a more comprehensive impact than one-way educational media. Conversely, we confirmed that attitude change was more challenging to achieve than knowledge improvement, consistent with Dahliana *et al.* [16], who report that anemia education significantly improves knowledge but not short-term attitudes.

From a theoretical perspective, our findings are consistent with the health belief model (HBM), which posits that increasing perceived susceptibility and perceived severity motivates individuals to adopt preventive behaviors [17]. The ANISA application provides information on risk factors, complications, and symptoms of anemia, thereby enhancing risk perception and strengthening behavioral intentions. Moreover, the TTM supports the finding that behavior change occurs gradually through stages of awareness, preparation, and repeated actions [18]. This explains why the improvement in attitude was smaller than that in knowledge, as attitude and behavior require longer-term reinforcement [19, 20]. The PRECEDE-PROCEED model is also relevant, emphasizing that predisposing factors such as knowledge, beliefs, and motivation play a fundamental role in shaping preventive behaviors [21].

The correlation between knowledge and attitude was reflected in the improvement of both parameters after the intervention, although the strength of the improvement varied. Theoretically, adequate knowledge contributes to the development of positive attitudes because pregnant women have a better understanding of the risks and benefits of anemia prevention behaviors [2, 4, 13, 22, 23]. However, despite a 100% increase in knowledge among the intervention group, attitude improvement was not uniform, as indicated by the 17 respondents who demonstrated no change. This suggests that other factors, such as personal experiences, environmental support, comfort with iron tablet consumption, and cultural influences, contribute to attitude formation. Thus, while there was a positive correlation between knowledge and attitude, it was neither deterministic nor linear.

The correlation between parameters was also evident in the group comparison, which showed that the intervention group demonstrated significantly higher post-test knowledge scores compared to the control group, which only received conventional counseling. However, for attitude, the between-group difference was not significant. This implies that digital media is highly effective in influencing cognitive aspects (knowledge) but less effective in influencing affective aspects (attitude) in the short term. This aligns with behavior change theory, which states that health behavior is shaped by a combination of knowledge, motivation, social support, and environmental conditions. While digital interventions may influence some predisposing factors, reinforcing and enabling factors require direct interaction, continued counseling, and repeated experiences [24-27].

The impact of this study is substantial for developing technology-based interventions in maternal health. The findings demonstrate that the ANISA application can serve as an effective educational alternative that is accessible, flexible, and practical for pregnant women. Moreover, this model can support healthcare workers in monitoring without necessitating frequent face-to-face interactions. The application has the potential to be integrated into maternal and child health (MCH) programs at primary health centers to strengthen health literacy and improve adherence to iron tablet consumption, ultimately contributing to a reduction in anemia prevalence during pregnancy in Indonesia. Long-term impacts may emerge if the application is further developed as a community and family-based digital monitoring system.

However, this study has several limitations. First, the pre-post design without an initial comparison group (in the development test) limits causal interpretation, although the final effectiveness test included a control group. Second, the relatively short intervention duration was insufficient to capture long-term changes in attitude and behavior. Third,

the study depended on smartphone ownership and internet access, which may introduce selection bias. Fourth, some respondents experienced ties (no change in scores), indicating the influence of other unmeasured factors such as fatigue, cultural beliefs, or personal preferences regarding iron tablet consumption. Additionally, minor technical issues, such as loading speed, were noted during the one-to-one and small-group evaluations.

The application was user-friendly, engaging, and provided educational and interactive features that help mothers recognize the risks of anemia, understand prevention strategies, and increase adherence to iron tablet consumption. These findings highlight that digital education can serve as an important support tool in reducing anemia among pregnant women, although sustained behavioral change still requires a longer process and strong environmental support.

Conclusion

The ANISA educational model, as a web-based digital education media, is both feasible and effective in improving pregnant women's knowledge and attitudes regarding anemia prevention.

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