Validating a mobile application for anemia prevention: Insights from expert feedback on AneMia_Prev®

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Abstract

Background: Anemia remains a critical public health issue among adolescents, particularly in developing countries such as Indonesia. Poor nutritional knowledge and limited awareness of anemia-related symptoms, etiology, and prevention exacerbate this condition. Mobile health (mHealth) technologies have the potential to address these gaps through accessible, engaging, and scalable education tools.
Purpose: This study aimed to validate the content of AneMia_Prev®, a mobile application designed as an educational tool to enhance adolescent knowledge on the prevention of anemia.
Methods: A Delphi technique was employed involving two rounds of expert panel review. Twelve experts with clinical and academic backgrounds in nursing and public health evaluated the content of AneMia_Prev® based on relevance, clarity, layout, illustrations, language, and motivational features. The Content Validity Index (CVI) and modified kappa statistics were used to assess inter-rater agreement and content adequacy. Data were collected through an online survey using a 17-item validated questionnaire.
Results: In the first round, all 17 items achieved excellent content validity with I-CVI values ranging from 0.87 to 1.00 and kappa values above 0.87. Following minor expert recommendations, a revised version of the application was re-evaluated, resulting in unanimous ratings of excellence (I-CVI = 1.00; kappa > 0.92 for all items). Experts emphasized the application's innovation, relevance, and potential to promote anemia awareness among adolescents.
Conclusion: AneMia_Prev® demonstrated excellent content validity and is considered suitable for educational interventions targeting anemia prevention among adolescents. Future research is recommended to assess semantic validation, cognitive impact, and learning outcomes among adolescent users to further refine the tool and evaluate its effectiveness in real-world settings.

Keywords: anemia prevention, content validation, delphi technique, mobile application

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Introduction

Anemia continues to be a pressing global health concern, particularly affecting adolescents during a critical stage of their physical and cognitive development. The World Health Organization (World Health Organization (WHO), 2023) reports that approximately one in four adolescents in developing nations suffer from anemia, with prevalence rates in Southeast Asia ranging between 27% and 55%. In Indonesia, this issue remains serious. Data from the 2018 national health survey indicate that 32% of individuals aged 15 to 24 years were affected by anemia (Mulianingsih et al., 2024). Notably, adolescent girls experienced higher rates compared to their male counterparts, with 22.7% and 12.4%, respectively (The Ministry of Health of Republic of Indonesia, 2018). When examined by region, rural communities demonstrated a slightly higher prevalence (37.8%) than urban areas (36.4%) (Statistik, 2020). Even more concerning, a local study

conducted in Serang, Banten Province, revealed that up to 92% of adolescents were anemic, with only 7.6% displaying hemoglobin levels within the normal range (The Ministry of Health of Republic of Indonesia, 2018). These figures highlight a growing public health challenge that demands targeted interventions. Effective responses may include comprehensive nutritional education, routine iron supplementation programs, and improved access to adolescent-centered health services (Mulianingsih et al., 2024; Saraswati, 2021).

Knowledge is an important determinant of anemia. Previous studies have noted that nutritional awareness has been argued to be strongly related to healthy living and healthy food preferences (Alaunyte et al., 2015). Previous study suggested that adolescents incorrectly answered certain questions such as symptoms of anemia which included dizzy eyes (79.0%), cold hands and feet (68.1%), rapid heart palpitations (80.7%), and nausea (88.2%) had more prevalent of anemia (Ghosal et al., 2020). More than 50% of adolescents lack knowledge of symptoms of anemia (Angadi & Ranjitha, 2016; Johnson et al., 2019). Cultural variables as well as perceived advantages of a specific diet impact food intake (Vosnacos & Pinchon, 2015a). In certain cases, female adolescent was also unaware of extreme anemia sequences (Vosnacos & Pinchon, 2015b). Adolescents need to know about the symptoms of anemia in order to predict themselves and take further measures to prevent and treat anemia when anemia occurs. However, previous studies were only focused on the knowledge related anemia symptoms not etiology of anemia or prevention and treatment of anemia. There is little information about the knowledge of female adolescent about anemia and the role of different dietary factors in causing anemia.

The usage of mobile technologies for health is rapidly rising. Because of their ease of use, extensive reach, and widespread acceptability, app features for exchanging health care information or real-time patient monitoring make them a valuable health tool. More than 53,000 medical apps were available in the Android Play Store (one of the primary download platforms) by the start of 2021 (Narrillos-Moraza et al., 2022). Diabetes (Kalhori et al., 2021; Kebede & Pischke, 2019), pain (Dantas et al., 2021; Kwan et al., 2019), rheumatic (Collado-Borrell et al., 2020; Terhorst et al., 2018), and psychiatric illnesses (Salehinejad et al., 2021; Singh, n.d.), as well as cancer (Ali et al., 2019; Amor-García et al., 2020; Jongerius et al., 2019), have all been targeted by medical apps. Apps for patients with hematological diseases are also available on the major download platforms, albeit there is little information available about them. However, there is limited uptake of online education platforms by adolescent due to lack of awareness and perceptions of low quality.

According to Dodt et al., (2012) and Fogg (2007), the development and application of mobile learning technologies have emerged as a tool to revolutionize learning and teaching as well as to foster new attitudes and behaviors in students. This viewpoint originated from the idea of the computer as a persuasive tool, which is known as Captology. Captology places an emphasis on the design, search for, and analysis of interactive goods (such as wireless technologies and mobile applications), which are intended to encourage people to change their attitudes and behaviors (Fogg, 2002). Additionally Fogg & Eckles, (2007) noted that the relevance of this kind of technology is supported by an emotional meaning due to the fact that it is omnipresent and has the power to facilitate problem solving and give knowledge at one's fingertips, without being constrained by time or distance.

Based on these considerations, we propose the development of a mobile application that will be called "AneMia-Prev." This application will be used as an online learning tool for teaching and learning about the prevention of anemia. However, in order to accomplish the goals that have been set, it is necessary to validate the content of the learning technology. Content validation involves systematic analysis and evaluation of reactions to theoretical concepts to determine if the tool has an adequate number of items to assess the material in general (Asch, 1998; Polit & Beck, 2010a; Wynd et al., 2003). Understanding the significance of the content validation process in achieving the objectives of the development of innovative educational technologies in the field of adolescent anemia prevention, this study aimed to describe the validation of a technology application content created for the purposes of learning and teaching about adolescent anemia prevention in our study.

Material and Methods

Design

This study adopted the Delphi technique as a structured and iterative method for reaching expert consensus regarding the content validity of the AneMia_Prev® mobile application (Keeney et al., 2011). Following the approach described by Keeney and colleagues and supported by Polit & Beck, (2010) the process involved multiple rounds of systematic input from a panel of experts. The validation process was conducted in eight distinct phases, beginning with the development of preliminary content and interface prototypes. This was followed by the construction of an evaluation tool, selection and invitation of suitable experts, and dissemination of the initial content along with the assessment instrument. Expert feedback from the first round was collected and synthesized to guide revisions. The updated version of the application and instrument was then redistributed for the second round of evaluation. Consensus was considered achieved once the second round demonstrated high levels of agreement and minimal new recommendations.

Twelve expert judges participated in the study, a sample size consistent with the guidelines proposed

by Rubio et al., (2003), which suggest six to twenty experts as sufficient for content validation using the Content Validity Index (CVI). The panel size was considered appropriate as data saturation was reached no substantial new input was introduced in the second evaluation round, and agreement across items was consistently strong (Keeney et al., 2011).

Study Setting and Panel Composition

The validation was conducted remotely through online communication platforms. Participants were drawn from the Indonesian provinces of Banten and West Java. To ensure appropriate expertise, selection criteria included a minimum of two years' professional experience as a registered nurse, advanced academic qualifications (master's or doctoral degrees, or specialist certification), and current employment in either higher education institutions or clinical public health services. Despite efforts to ensure diversity, the panel composition skewed toward academic professionals, comprising approximately two-thirds of the sample.

Mobile Application Development

The educational content for the AneMia_Prev® application was developed in alignment with official guidelines from the Ministry of Health of Indonesia and the World Health Organization. The app features several learning tools and resources, including foundational information about anemia, dietary guidance, food intake diaries, nutrition tracking tables, animated educational videos, interactive quizzes, and a function for virtual consultation. These features were designed to support adolescent users in understanding and preventing anemia in a user-friendly, accessible format (Figure 1).

Data collection and Evaluation Instrument

The expert panel received access to the application prototype along with a structured online questionnaire for content evaluation, distributed via Google Forms. The instrument was adapted from a validated tool developed by (de Souza Menezes et al., 2012) and consisted of 17 statements covering five key areas: content clarity, language appropriateness, relevance of visual illustrations, layout and design, and motivational impact (Table 1). Experts rated each item using a five-point Likert scale ranging from "strongly disagree" to "strongly agree." Additionally, space was provided for open-ended comments to encourage detailed feedback and suggestions for improvement.

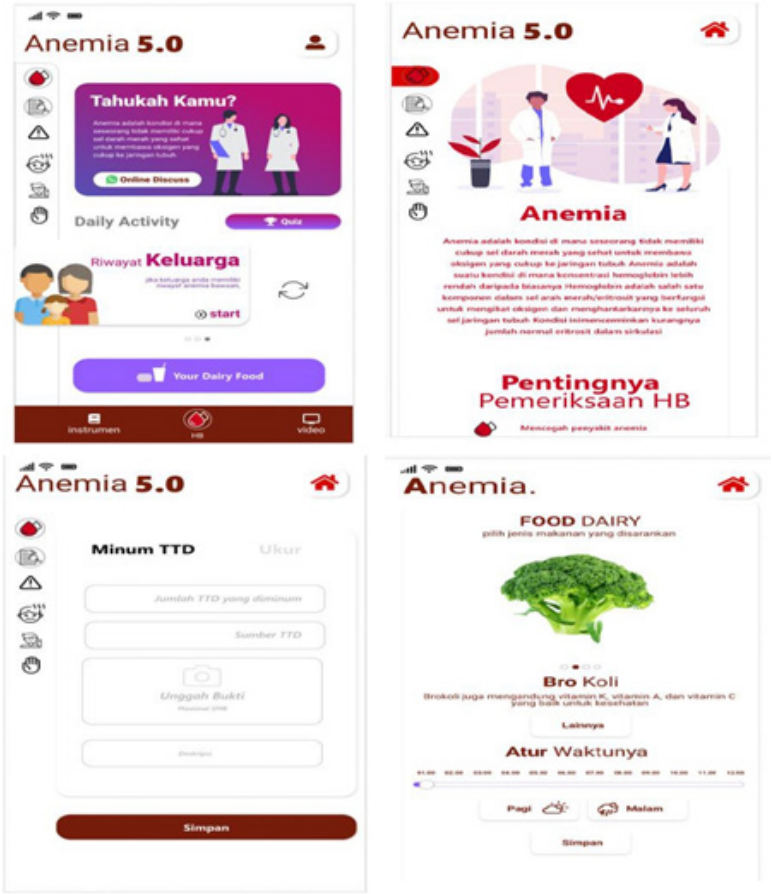

Figure 1. "AneMia_Prev®" mobile application

Table 1. Assessment instrument used in the study adopted from Souza and Turrini (2012)

	Item	5	4	3	2	1
Content	Is the content suitable for the intended audience?					
	Is the content division sufficient?					
	Is the content adequate for anemia prevention education?					
	Is the order of the menu logical and consistent?					
	Is the writing approach appropriate for the intended audience?					
Language	Is writing visually appealing?					
	Is the terminology objective and transparent?					
	Are the illustrations relevant to the content? Do they aid in elucidating the content?					
Illustrations	Are illustrations legible? Do they facilitate understanding?					
	Is the letter style suitable for reading?					
	Is the text layout appropriate for the screen?					
Layout	Is the letter size appropriate?					
	Is the visual arrangement appealing and well-organized?					
	5. Is the number of displays appropriate for the content?					
Motivation	Is the content interesting? Does it encourage the intended audience to proceed?					
	Is the text engaging to the reader?					
	Is the information essential for understanding about anemia prevention?					

Table 2. Content validation in the first round

Item	Expert	Mean	SD	Score 4 to 5	I-CVI[1]	Kappa[2]	Criteria[3]
1	12	4.32	0.52	11	0.90	0.90	Excellent
2	12	4.12	0.47	10	0.87	0.87	Excellent
3	12	4.45	0.49	12	0.92	0.92	Excellent
4	12	4.51	1.11	11	1.00	1.00	Excellent
5	12	4.24	0.76	11	0.92	0.92	Excellent
6	12	4.87	0.34	12	1.00	1.00	Excellent
7	12	4.43	1.21	12	1.00	1.00	Excellent
8	12	4.57	1.08	11	0.32	0.32	Excellent
9	12	4.60	0.78	10	0.90	0.90	Excellent
10	12	4.26	0.66	10	1.00	1.00	Excellent
11	12	4.38	0.75	11	0.90	0.90	Excellent
12	12	4.45	0.50	11	1.00	1.00	Excellent
13	12	4.49	0.63	10	0.93	0.93	Excellent
14	12	4.57	0.43	12	1.00	1.00	Excellent
15	12	4.66	0.71	10	0.91	0.91	Excellent
16	12	4.55	0.45	10	0.87	0.87	Excellent
17	12	4.83	1.32	11	0.90	0.90	Excellent

Note:
[1] I-CVI, item-content validity index.
[2] Modified kappa: k = (i-CVI − pc) / (1 − pc).
[3] The following definitions apply to the k statistic: Poor = k between 0.40 and 0.59, Good = k between 0.60 and 0.74, and Excellent = k > 0.74.

Table 3. Content validation in the second round

Item	Expert	Mean	SD	Score 4 to 5	I-CVI[1]	Kappa[2]	Criteria[3]
1	12	4.83	0.11	12	1.00	1.00	Excellent
2	12	4.83	0.23	12	1.00	1.00	Excellent
3	12	4.83	0.15	12	1.00	1.00	Excellent
4	12	4.75	0.19	11	0.92	0.92	Excellent
5	12	4.75	0.52	11	0.92	0.92	Excellent
6	12	4.92	0.24	12	1.00	1.00	Excellent
7	12	4.92	0.23	12	1.00	1.00	Excellent
8	12	5.00	0.00	12	1.00	1.00	Excellent
9	12	4.75	0.04	11	0.92	0.92	Excellent
10	12	4.92	0.17	12	1.00	1.00	Excellent
11	12	4.83	0.17	12	1.00	1.00	Excellent
12	12	4.92	0.22	12	1.00	1.00	Excellent
13	12	5.00	0.00	12	1.00	1.00	Excellent
14	12	4.92	0.12	12	1.00	1.00	Excellent
15	12	4.92	0.71	12	1.00	1.00	Excellent
16	12	4.92	0.15	12	1.00	1.00	Excellent
17	12	5.00	0.00	12	1.00	1.00	Excellent

Note:
[1] I-CVI, item-content validity index.
[2] Modified kappa: k = (i-CVI − pc) / (1 − pc).
[3] The following definitions apply to the k statistic: Poor = k between 0.40 and 0.59, Good = k between 0.60 and 0.74, and Excellent = k > 0.74.

Table 4.

Aspect	First Round Feedback	Actions Taken Before Round Two
Character and visual design	Characters were perceived as too generic and less culturally relevant	Characters updated with more localized, relatable designs and simplified animations
Language and grammar	Complex sentence structures; minor grammatical inconsistencies	Language was revised for clarity, age-appropriate vocabulary, and grammatical accuracy
Menu layout and navigation	Some menus perceived as cluttered or redundant	Streamlined menu structure; reduced information density per screen
Educational content	Mostly positive, though suggestions for reorganizing anemia etiology and treatment flow	Educational flow restructured into clearer modules: etiology → symptoms → prevention
Motivation and engagement	High engagement reported; minor feedback on enhancing interactivity	Quizzes were redesigned to include immediate feedback and gamified scoring

Integration of Expert Feedback

Qualitative comments were systematically reviewed and organized into thematic categories. These categories included changes deemed essential due to clinical or linguistic inaccuracy, those considered beneficial but not mandatory, suggestions based on personal preference or style, and those not aligned with the goals or capabilities of the app. Recommendations identified as critical or strongly advised were prioritized and incorporated into the updated version of the application. Suggestions not implemented were carefully reviewed, and the rationale for exclusion was documented based on relevance, feasibility, and target-user suitability.

Data Analysis

Quantitative data from expert ratings were analyzed using the Item Content Validity Index (I-CVI) and modified kappa statistics (Polit et al., 2007).The I-CVI was calculated by dividing the number of experts assigning a rating of 4 or 5 to an item by the total number of experts (Oliveira et al., 2008; Reberte et

al., 2012; Sousa & Turrini, 2012). An I-CVI score of 0.78 or higher was considered to reflect acceptable content validity. The modified kappa coefficient was used to determine the degree of agreement beyond chance, with values interpreted as follows: scores between 0.40 and 0.59 were considered poor, 0.60 to 0.74 as good, and 0.75 or higher as excellent. The analysis was conducted using SPSS software. Qualitative responses from the open-ended sections were analyzed thematically to complement and triangulate the quantitative findings.

Ethical consideration

The study was approved by the STIKep PPNI Jawa Barat Ethical and Research Committee (0189/KEPK/STIKep/PPNI/Jabar/XI/2022). All participants provided informed consent after receiving a full explanation of the study's objectives, methods, and voluntary nature. To ensure confidentiality, all expert responses were anonymized using alphanumeric codes.

Result

Twelve of the twenty experts who were invited to participate in the study. The majority were females (83.3%), with ages ranging from 37 to 45 years, residing in Banten and Bandung, and holding either a master's degree (41.7% of respondents) or a PhD (58.3% of respondents). Approximately 66.7% had more than ten years of experience as nurse nursing faculty members, and 33.3% had more than ten years of experience as registered nurses. The majority of specialists held positions in academic institutions.

In the first round of the competition, all of the panel of experts participated in the evaluation process by answering a series of questions posed by the AneMia_Prev® instrument. This was done in order to determine the overall quality of each of the 56 individual screens (Table 2).

The panel of experts made several specific ideas for improvements, such as changing the characters' look, altering the meaning of phrases, and adjusting the language to better comprehend the intended audience. No recommendations were made about structure. A new content version, consisting of 63 screens, was developed once all feedback was incorporated. The judges have been provided with this revised submission (Table 3).

The content validation process was completed over two Delphi rounds with participation from 12 expert panelists. In the first round, quantitative results demonstrated strong agreement across most items, with I-CVI values ranging from 0.87 to 1.00 and modified kappa values reflecting excellent inter-rater reliability. However, qualitative feedback provided essential insights into areas needing revision and improvement. Analysis of open-ended expert comments revealed three primary themes, namely visual and character design adjustments, linguistic clarity and readability, and pedagogical and motivational appeal.

Visual and Character Design Adjustments

Experts noted that certain design elements, particularly character illustrations and interface icons, did not align with adolescent preferences. These concerns centered on the appeal and relatability of visual features.

"Character design should be more youthful and culturally relevant to Indonesian adolescents." (Expert 6)

"Simplify some of the animations. They may be distracting rather than educational." (Expert 9)

Linguistic Clarity and Readability

Several experts emphasized the importance of revising sentence structure and grammar for better clarity and engagement. Suggestions were made to simplify language while maintaining scientific accuracy to suit the target adolescent demographic.

"Some text is too academic; simplify wording without losing the message." (Expert 2)

"Adjust grammar to match adolescent literacy levels for better engagement." (Expert 8)

Pedagogical and Motivational Appeal

Despite the constructive criticism, feedback also showed consensus on the app's strong potential for educational impact and user motivation. Experts appreciated the integration of quizzes, videos, and consultation features as engaging and behaviorally persuasive.

"The use of quizzes and interactive features is excellent for reinforcing learning." (Expert 11)

"This is an innovative digital intervention that has real potential to reach adolescents at scale." (Expert 4)

The following table outlines the modifications made between the first and second validation rounds, guided by both quantitative scores and thematic feedback (Table 4).

After integrating these changes, the second round of evaluation yielded perfect or near-perfect scores across all 17 items. Every item achieved an I-CVI of 0.92–1.00, and all modified kappa values were categorized as excellent ($\kappa > 0.75$). Experts indicated strong consensus, and no new themes or recommendations emerged, signaling data saturation. Overall, expert ratings and feedback indicated that AneMia_Prev® was a well-designed, contextually appropriate, and pedagogically sound tool for adolescent anemia prevention education. The high degree of consensus after the second round confirmed the tool's readiness for future pilot testing and implementation studies.

Discussion

This study sought to validate the content of AneMia_Prev®, a mobile-based educational application developed to promote anemia prevention among adolescents. Using a structured Delphi methodology,

the validation process involved iterative expert review, culminating in high levels of consensus regarding the app's content relevance, linguistic clarity, interface design, and pedagogical structure. Notably, the two-phase validation led to meaningful refinements, resulting in all 17 evaluated items attaining excellent content validity indices (CVI ≥ 0.92), reflecting enhanced instructional quality, consistency, and clarity.

Aligning with the principles outlined by Teixeira & Mota, (2011), the use of expert panels served as a rigorous and theory-informed strategy for refining digital educational interventions. Throughout the process, experts offered multidimensional feedback ranging from linguistic precision and visual effectiveness to conceptual coherence and interface usability. This depth of input, both qualitative and quantitative, exemplifies the value of collaborative refinement, echoing Walker (2013) perspective on the need for tailoring health education tools to the cognitive and emotional profiles of their intended users.

The results confirmed that the application's language was appropriately adapted to the comprehension level of adolescents, combining clarity with an engaging tone. This is particularly relevant, as research underscores the role of accessible and relatable language in improving learning outcomes among younger audiences (Preti, 2010; Teixeira & Mota, 2011). Visual components were also seen as a major asset, experts praised their ability to reinforce semantic understanding and support content retention, consistent with insights from Berglund et al., (2024) and Xelegati & Évora (2011), who stress the importance of integrating visuals and text to foster memory and meaningful learning.

Further supporting its theoretical foundation, AneMia_Prev® integrates the concept of persuasive technology as introduced by Fogg & Eckles (2007). The app is not limited to information delivery; rather, it seeks to promote sustained behavior change by encouraging proactive health behaviors through interactive features. The inclusion of gamified quizzes, self-assessment tools, and personalized feedback mechanisms reflects the principles of captology deliberately shaping user experiences to influence actions, particularly in the realm of preventive adolescent health.

From a practical perspective, the findings of this study offer valuable contributions to both nursing education and community health practice. Emphasizing the importance of integrating age-appropriate, evidence-based digital tools into health promotion strategies, the AneMia_Prev® application presents an opportunity to be applied in clinical and community settings. In these environments, nurses are well-positioned to actively engage adolescents in health education, reinforcing critical information through digital platforms. Furthermore, the validation framework outlined in this study may serve as a foundation for the future design of educational technologies aimed at preventing other modifiable health conditions. By incorporating digital interventions grounded in educational theory and behavioral science, nursing professionals can enhance health literacy and support proactive health behaviors, particularly among at-risk youth populations.

However, certain limitations should be acknowledged. While the panel of experts brought significant academic experience, the limited representation from clinical practitioners, public health professionals, and adolescent users themselves may have restricted the breadth of perspectives considered. Furthermore, the current validation phase was expert-driven, lacking direct input from the primary target users—adolescents. This omission limits the assessment of user comprehension, cognitive load, and real-world usability.

To advance the application's development, subsequent research should involve adolescents in usability testing and pilot implementation. Understanding how users interact with the app, identifying which features drive engagement, and determining whether knowledge gains translate into preventive behavior will be essential. Additionally, incorporating AneMia_Prev® into school-based health programs or broader digital health initiatives may amplify its reach and impact. Collaborating with developers, nutrition experts, and educators could further enhance the tool's functionality, cultural relevance, and scalability.

Nursing implication

The development and validation of AneMia_Prev® have major consequences for nursing practice, particularly in the field of promoting the health of adolescents. It is possible for nurses, who play an important role as educators and advocates for preventive health, to make use of digital tools like AneMia_Prev® in order to enhance the health literacy of adolescents specifically with regard to iron deficiency anaemia. By incorporating this application into school-based health programs, community outreach projects, and regular nursing education programs, nurses are able to give information that is standardised, based on research, in a way that is both engaging and accessible. Adolescents are able to adopt better eating habits and preventative measures with the assistance of nursing tactics that are focused on behaviour modification, which are aligned with the incorporation of persuasive design concepts. It is possible for nurses, in their capacity as frontline providers, to make a contribution to the iterative improvement of digital treatments by participating in usability tests and providing feedback from relevant clinical and community settings. The use of AneMia_Prev® in nursing practice has the potential to improve preventive health education, reduce the prevalence of anaemia in adolescents, and contribute to broader public health goals by using technology-driven approaches that are

culturally appropriate.

Limitation of the study

The experts recruited in this study mostly from academic setting. This homogeneity may restrict the generalizability of the results, underscoring the importance of including a more diverse group in future studies. Broader representation from dietitians, software developers, public health workers, and adolescent users would help ensure that the content is relevant, comprehensive, and contextually appropriate.

Conclusion

In conclusion, the findings from this study indicate that AneMia_Prev® possesses strong content validity and is grounded in well-established educational and behavioral science frameworks. It represents a promising model for the design of learner-centric digital health tools, particularly within adolescent nursing education. By integrating principles of persuasive design with evidence-based pedagogy, this intervention has the potential to significantly improve adolescent health literacy and contribute to the reduction of iron deficiency anemia as a preventable yet widespread condition.

Although expert validation confirmed the application's content quality and its alignment with adolescent health education needs, additional research is essential to enhance its practical effectiveness. Future investigations should prioritize usability testing involving adolescents to assess how well they engage with the app, understand the content, and navigate its features. It is also important to examine how cultural and language differences might influence user experience, ensuring the application remains relevant and meaningful across various demographic segments. Furthermore, long-term studies are recommended to evaluate the app's ongoing impact on adolescent health behaviors, particularly in areas such as nutritional choices, iron supplement use, and efforts to prevent anemia. With ongoing improvements guided by real-world feedback, AneMia_Prev® has the potential to evolve into a widely adopted, user-friendly digital learning tool that supports anemia prevention and health promotion among adolescents in Indonesia and other global settings.

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Declaration of interest

All authors declare no conflict of interest

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Data Availability

None

Reference

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