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Development and Usability Testing of HemoGirl, an Android-Based Application for Anemia Education among Adolescent Girls

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ABSTRACT

Introduction: Mobile health applications represent an innovative strategy to strengthen health promotion by improving the accessibility and delivery of nutrition-related information, particularly anemia education among adolescent girls. Adolescence is a critical period characterized by increased nutritional demands and vulnerability to iron deficiency anemia, which can adversely affect growth, cognitive performance, and future reproductive health. Given the limitations of conventional educational approaches in engaging adolescents, interactive digital interventions have emerged as a promising alternative. Therefore, this study aimed to develop the HemoGirl mobile application and evaluate its preliminary usability and user acceptance among adolescent girls.
Methods: This study employed a Research and Development design using the Waterfall model, encompassing requirement analysis, system design, development, testing, and maintenance. Usability testing was conducted among 61 first-year adolescent girls aged 17–19 years recruited through convenience sampling. Participants attended a supervised usability testing session lasting approximately 60 minutes, during which they used the HemoGirl application and completed predefined tasks before evaluating the system using the System Usability Scale (SUS). The SUS consists of 10 standardized items rated on a five-point Likert scale and assesses usability, ease of use, and user satisfaction.
Results: The usability evaluation yielded a mean SUS score of 78 ± 12.7, indicating good usability and acceptable user satisfaction. Participants generally perceived the application as easy to learn, simple to navigate, and appropriate for accessing anemia-related educational content. These findings suggest that the HemoGirl prototype was well accepted by its intended users and met established usability standards.
Conclusion: The HemoGirl mobile application demonstrated good usability and user acceptance among adolescent girls. As a prototype for anemia education and self-monitoring, the application shows promise as a digital health promotion tool. However, further longitudinal and experimental studies are required to evaluate its effectiveness in influencing knowledge, health behaviors, and anemia-related outcomes.

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INTRODUCTION

Anemia among adolescents remains a significant public health concern in Indonesia, with national survey data indicating that approximately one-third of adolescents are affected (1). At the regional level, the rates vary substantially, ranging from 20.9 percent among adolescent girls in Bogor City (2) to as high as 45.6 percent in Bogor Regency (3). The burden of anemia is unevenly distributed across regions, with prevalence estimates ranging from moderate to high levels in several districts, underscoring its persistent and widespread nature. This condition is classified as a moderate public health problem and warrants sustained preventive efforts. Anemia, characterized by hemoglobin concentrations below the recommended threshold of 12 g/dL, compromises the blood's oxygen carrying capacity and adversely affects physical and cognitive functioning. Adolescents with anemia commonly experience fatigue, reduced stamina, impaired concentration, and breathlessness, which can interfere with daily activities and overall well-being during a critical stage of growth and development (4).

The etiology of anemia in adolescent girls is complex and multifaceted. Increased physiological iron requirements associated with rapid growth and the onset of menstruation place adolescent girls at heightened risk. These demands are frequently unmet due to insufficient intake of iron and other essential nutrients. In addition to biological factors, socio behavioral determinants such as limited dietary diversity, unhealthy eating patterns, and inadequate knowledge regarding iron-rich foods further exacerbate the problem (5). If left unaddressed, anemia during adolescence may lead to immediate consequences, including decreased physical endurance and suboptimal academic performance, as well as long term effects such as increased risks of maternal anemia, adverse pregnancy outcomes, and intergenerational malnutrition (6,7). These potential outcomes highlight adolescence as a critical window for effective anemia prevention.

To address this challenge, the Indonesian government has implemented the Gerakan Nasional Aksi Bergizi, a school-based health promotion initiative that includes the weekly provision of iron and folic acid supplements to adolescent girls. Each supplement contains 60 mg of elemental iron and 400 µg of folic acid and is intended to prevent iron deficiency anemia (8). Despite relatively high coverage in terms of supplement distribution, adherence remains alarmingly low. A substantial gap persists between reported receipt of supplements and regular consumption as recommended. This gap has been attributed to factors such as forgetfulness, limited understanding of anemia and its health implications, low perceived benefits of supplementation, and insufficient reinforcement from teachers, parents, and peers (9). In addition, schools often encounter difficulties in systematically monitoring and reporting supplement intake, which hampers program evaluation and accountability (10).

Previous studies have identified several structural and operational barriers that limit the effectiveness of school-based anemia prevention programs (11). Educational media specifically tailored to anemia prevention are limited, and the role of teachers as active facilitators of health promotion has not been fully optimized (12). Furthermore, monitoring practices frequently rely on manual or verbal reporting methods, resulting in inconsistencies and reduced data reliability. These challenges point to a disconnect between policy objectives and implementation at the operational level, indicating the need for innovative strategies that combine health education with efficient monitoring and reporting systems (13).

Despite the growing adoption of mobile health (mHealth) interventions for adolescent health promotion, important gaps remain in the development and evaluation of digital tools for anemia prevention. Existing applications targeting adolescent health generally focus on information delivery, while only a limited number incorporate features that support self-monitoring, adherence promotion, or stakeholder involvement (14–16). Furthermore, previous interventions differ substantially in their target populations, behavioral support mechanisms, monitoring capacities, and evaluation outcomes, making it difficult to determine how digital platforms can effectively support school-based anemia prevention programs (17). While some applications have demonstrated improvements in knowledge and user engagement, integrated platforms that combine anemia education, iron–folic acid supplementation monitoring, nutritional assessment, menstrual health tracking, and institutional reporting remain scarce, particularly in low- and middle-income settings (18).

From a theoretical perspective, integrated digital interventions may enhance preventive health behaviors by combining educational, motivational, and self-regulatory components. Guided by the Health Belief Model and Self-Regulation Theory, educational content can increase awareness of anemia susceptibility and consequences, reminder systems can function as cues to action, and self-recording features can facilitate self-monitoring and habit formation

(19,20). In addition, the involvement of teachers and health workers may strengthen accountability and reinforce adherence behaviors through external support and monitoring. These mechanisms suggest that a comprehensive digital platform may offer advantages over information-based interventions alone.

Before the effectiveness of such interventions can be evaluated in terms of knowledge improvement, supplementation adherence, or health outcomes, it is essential to establish that the application is usable, acceptable, and capable of supporting intended user interactions. Usability testing represents a critical early stage in digital health intervention development because poor usability may limit engagement and reduce the potential effectiveness of even well-designed behavioral interventions. Therefore, the novelty of HemoGirl lies not only in its integrated and role-based design, which connects adolescent girls, teachers, and health workers within a single platform, but also in its development as a user-centered digital tool that combines educational, behavioral support, and monitoring functions.

Given the persistent burden of anemia and the limited evidence regarding the usability of integrated mHealth platforms for adolescent anemia prevention, it is essential to evaluate the feasibility and acceptability of HemoGirl before broader implementation. Therefore, this study aimed to develop the HemoGirl mobile application and evaluate its user acceptance through usability testing among adolescent girls. The findings are expected to contribute to the growing literature on digital health promotion and inform the development of technology-assisted strategies for adolescent nutrition and anemia prevention.

METHOD

Research Type

This study employed a Research and Development (R&D) design to develop and evaluate a mobile health application for anemia education among adolescent girls. The application development process followed the Waterfall model, which consists of sequential and systematic phases, including requirement analysis, system design, development, testing, and maintenance. This model was selected to ensure a structured development process and to produce a functional application that met predefined user and system requirements.

Population and Sample

The study population comprised female students enrolled at the Vocational School of IPB University. The sample size of 61 participants was considered adequate for usability testing studies, as previous research has suggested that a sample of 30–60 users is sufficient to identify the majority of usability issues and generate stable SUS estimates (21). The inclusion criteria were female students aged 17–19 years recruited through convenience sampling, enrolled in the first semester, able to operate an Android smartphone, and willing to participate in the study. Students who were absent during the usability testing session or unable to complete all study procedures were excluded from the analysis.

Research Location

The study was conducted at the Vocational School of IPB University, Bogor, Indonesia. Data collection and usability testing took place between June and September 2025.

Instrumentation and Tools

The primary instrument used to assess usability was the System Usability Scale (SUS), a standardized and widely validated questionnaire for evaluating the usability of digital systems. The SUS consists of 10 items rated on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Items with odd numbers reflect positive user perceptions, whereas even-numbered items represent negative user perceptions. In addition to the questionnaire, direct observation was conducted to assess user interaction with application features, including navigation, interface clarity, comprehension of educational content, and functionality related to iron and folic acid (IFA) tablet monitoring (22).

Data Collection Procedures

During the requirement analysis phase, a user-centered approach was adopted to identify the needs and expectations of key stakeholders. The needs assessment involved adolescent girls, teachers, and health workers

through semi-structured interviews and focus group discussions (FGDs). These activities explored participants' experiences, challenges, and preferences related to anemia education, IFA supplementation, adherence monitoring, and health information access. The findings were subsequently translated into application requirements and used to define the core functionalities of HemoGirl, including educational modules, IFA intake reminders, self-monitoring tools, menstrual cycle tracking, and monitoring and reporting features for teachers and health workers.

The system design phase focused on translating user and functional requirements into application architecture, interface design, and workflow specifications. The development of educational content within the application was guided by evidence-based recommendations on adolescent nutrition and anemia prevention (8). All educational materials, including information on anemia, iron-rich foods, balanced nutrition, and IFA supplementation, were reviewed and validated by a nutrition expert to ensure scientific accuracy, relevance, and age appropriateness for adolescent users. The development process began with a needs assessment to identify user and stakeholder requirements, which informed the system specifications.

Following application development, usability testing was conducted as part of the system testing phase. Participants were instructed to download the HemoGirl application from the Google Play Store and complete a series of predefined tasks designed to simulate typical user interactions. Specifically, participants were asked to: 1) download and install the application; 2) log in using the credentials provided by the researchers; 3) access the IFA tablet intake recording feature and record a supplementation entry; 4) use the nutritional status assessment feature by entering their body weight, height, and date of birth to obtain a BMI-for-age nutritional status classification; 5) view the anemia educational videos available within the application; 6) explore the balanced nutrition menu recommendations; and 7) use the menstrual calendar feature by entering the first day of their most recent menstrual period. These tasks were selected to ensure that participants experienced the main functionalities of the application prior to the usability evaluation.

The usability testing session was conducted in a supervised setting, with all participants gathered in a single classroom under the guidance of the research team. No direct assistance related to task completion was provided unless technical difficulties occurred that could prevent application access. The entire session lasted approximately 60 minutes, including application use and questionnaire completion. After completing all assigned tasks, participants independently completed the SUS questionnaire to assess the usability, ease of use, and overall acceptability of the HemoGirl application. Finally, the maintenance phase included system evaluation, performance improvement, and future feature enhancement.

Data Analysis

Usability data obtained from the SUS questionnaires were analyzed quantitatively. For positive items, one point was subtracted from the participant's response score, while for negative items, the response score was subtracted from five. The adjusted scores for all items were summed and multiplied by a factor of 2.5 to generate a total SUS score ranging from 0 to 100. Mean SUS scores were calculated to determine the overall usability level of the application. Based on established interpretation guidelines, scores of 50 or below were categorized as *not acceptable*, scores above 50 up to 70 were considered *marginal*, and scores greater than 70 were classified as *acceptable*. These criteria were used to evaluate the feasibility and acceptance of the HemoGirl application as a digital health promotion tool (23).

Ethical Approval

This research received ethical approval from the Health Research Ethics Committee of the Faculty of Nursing and Health, Universitas Muhammadiyah Semarang Number 537/KE/06/2025.

RESULTS

Development of the HemoGirl Application

The HemoGirl mobile application was developed as a role-based digital platform to support anemia education and iron–folic acid (IFA) supplementation programs among adolescent girls. The system accommodates three categories of users: adolescent girls, teachers, and health workers. Based on the requirements analysis, adolescent users can access features for self-recording of IFA tablet consumption, nutritional status assessment, anemia

educational videos, balanced meal recommendations, and menstrual cycle tracking. Teachers and health workers are provided with monitoring and reporting functions to oversee students' IFA supplementation adherence. The interactions among user roles and system functions are presented in the use-case diagram (Figure 1).

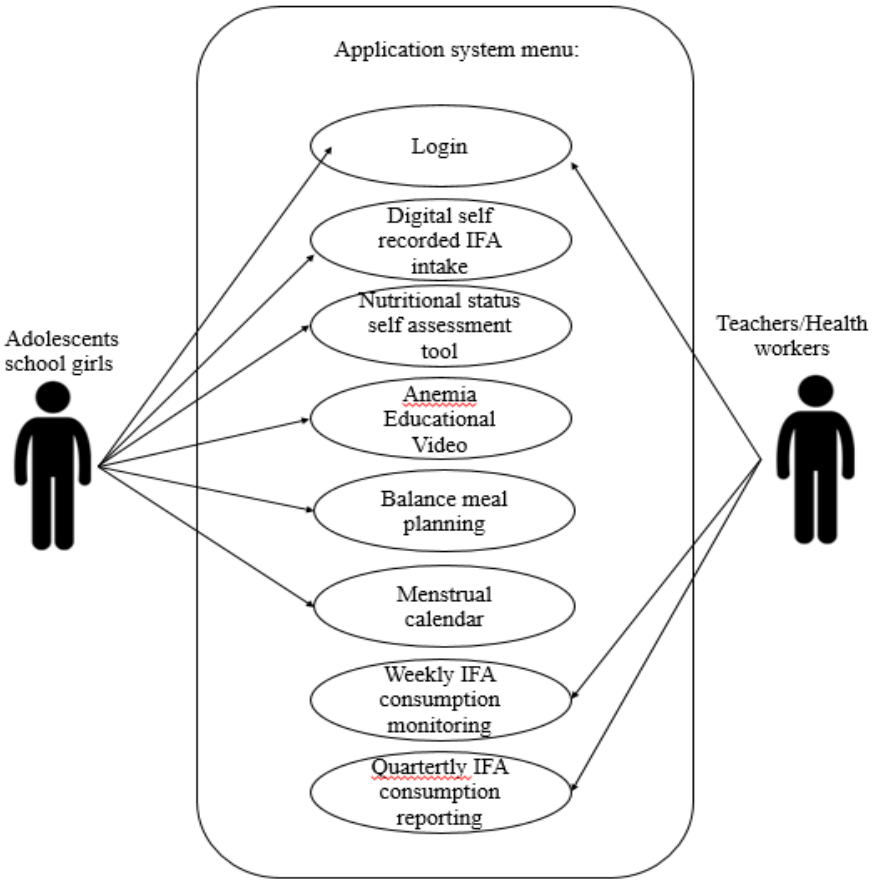

Figure 1. Use case diagram

The application incorporates user authentication and role-specific dashboards to ensure appropriate access to system functions. The nutritional status assessment feature enables users to enter body weight, height, and date of birth, allowing automatic calculation of BMI-for-age Z-scores and nutritional status classification. In addition, the application integrates educational content, self-monitoring tools, and menstrual tracking features designed to support anemia awareness and preventive behaviors. Monitoring and reporting modules are available for teachers and health workers to facilitate program supervision and documentation (Figures 2–6).

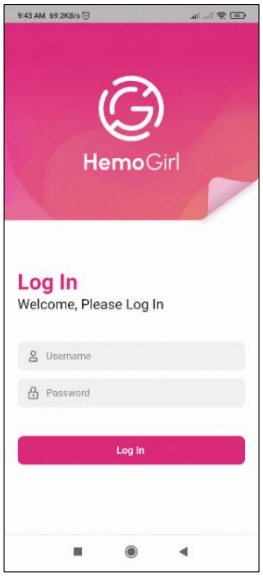

Figure 2. Splash screen

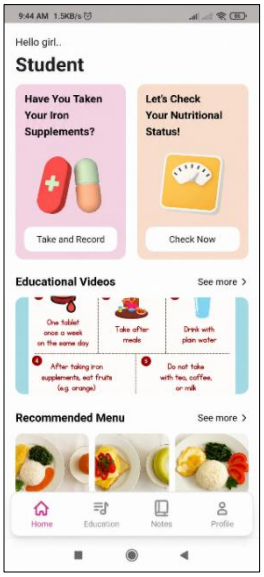

Figure 3. Adolescent girls dashboard

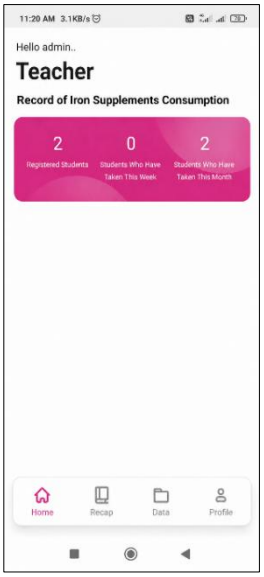

Figure 4. Teacher or health worker dashboard

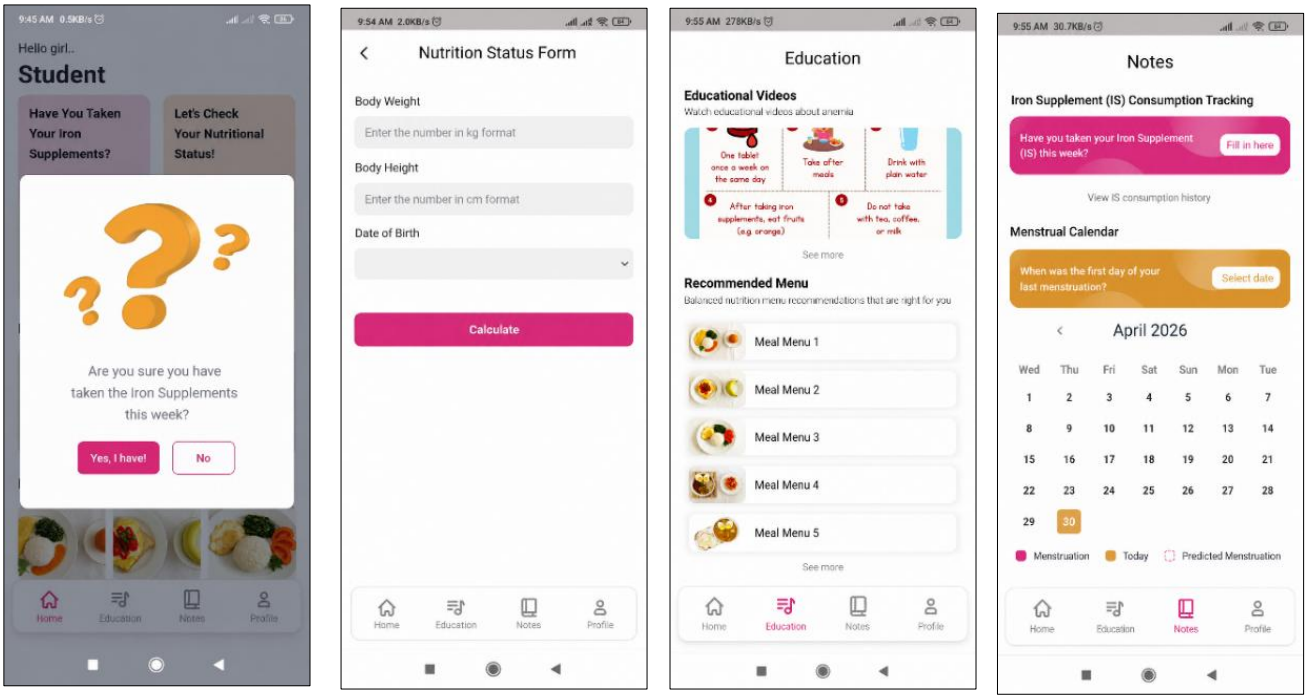

Figure 5. Application features for adolescent girls

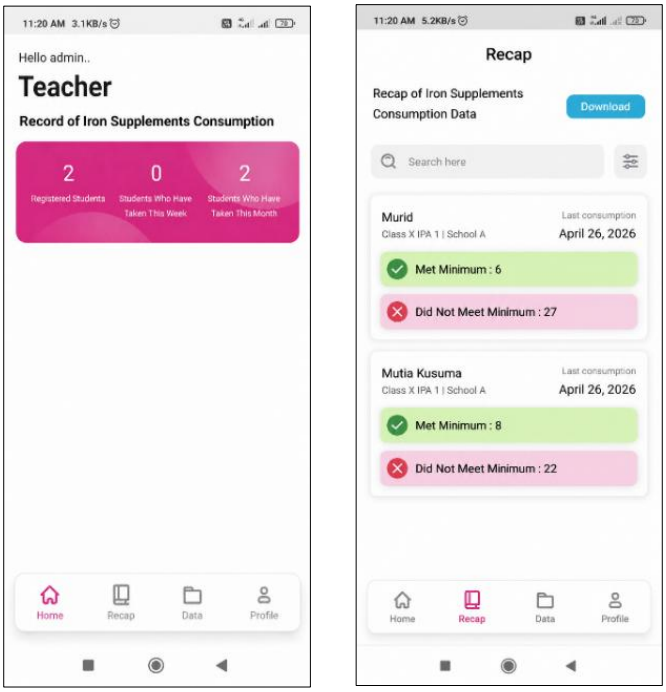

Figure 6. Application features for teachers and health workers

Usability Testing Results

A total of 61 adolescent girls participated in the usability testing of the HemoGirl application. All participants were female, with a mean age of 18.2 ± 0.5 years, ranging from 17 to 19 years. The overall usability assessment yielded a mean SUS score of 78.0 ± 12.7, with scores ranging from 42.5 to 100. Based on the standard SUS acceptability classification, the majority of participants (80.4%) rated the application within the acceptable category, indicating a favorable level of usability and user acceptance. In contrast, 18.0% of participants were classified within the marginal category, while only 1.6% rated the application as not acceptable. These findings suggest that the HemoGirl application was generally perceived as easy to use and well accepted by its intended users. Participant characteristics and usability assessment results are presented in Table 1.

Table 1. Participant characteristics and usability assessment results

Variable	Value
Age (years)	18.2 ± 0.5
Minimum-Maximum (years)	17-19
Female, n (%)	61(100.0)
SUS Score	78 ± 12.7
Minimum-Maximum SUS Score	42.5-100
Acceptability Categories	
Not Acceptable, n(%)	1(1.6)
Marginal, n (%)	11(18.0)
Acceptable, n (%)	49 (80.4)

Overall, 82.6% of responses reflected favorable perceptions of the application, while 13.1% were neutral and 4.3% were unfavorable. A more detailed examination of individual SUS items revealed several important usability patterns. The highest ratings were observed for Item 8 (“I found the application cumbersome to use”) and Item 7 (“I believe most people would learn to use this application very quickly”), both with a mean score of 8.5. These findings suggest that participants generally perceived the application as easy to learn and not burdensome to

operate. High ratings were also obtained for Item 3 ("I thought the application was easy to use") (8.6 ± 1.7) and Item 9 ("I felt very confident using this application") (8.1 ± 1.8), indicating positive user experiences related to usability and confidence (Table 2).

Despite the generally favorable evaluations, several items received comparatively lower scores. Item 10 ("I needed to learn many things before I could get going with this application") obtained the lowest mean score (5.9 ± 2.7). Although nearly half of the participants expressed positive perceptions, a substantial proportion reported neutral (27.9%) or negative responses (23.0%). This finding suggests that some users required additional familiarization before confidently using all application features. Similarly, Item 4 ("I think I would need the support of a technical person to be able to use this application") received a lower score (7.1 ± 2.2) compared with other items, indicating that a small proportion of users perceived a need for assistance during initial use. These findings highlight opportunities to improve onboarding instructions, feature guidance, and interface clarity for first-time users (Table 2).

Direct observations conducted during the usability testing session provided additional insights into user interaction with the application. Most participants were able to complete the assigned tasks successfully without direct assistance. However, several users required additional time to locate specific functions, particularly the nutritional status assessment and menstrual calendar features. Minor hesitation was also observed when participants entered anthropometric data and recorded menstrual information for the first time. Some users sought clarification regarding the interpretation of nutritional status results and the procedure for recording supplementation intake. Nevertheless, all participants completed the required tasks within the allocated session, suggesting that the identified difficulties were minor and primarily related to initial familiarization rather than fundamental usability problems. These observations are consistent with the item-level SUS findings, particularly the relatively lower scores on items related to confidence during initial use and the need to learn certain aspects of the system before using it effectively. The observed difficulties were limited to first-time interactions and did not prevent task completion, suggesting that the application possesses good overall usability while still offering opportunities to improve onboarding instructions and feature discoverability.

Table 2 presents the item-level distribution of SUS responses on adolescent girl's respondents. To facilitate interpretation, responses to negatively worded items (Items 2, 4, 6, 8, and 10) were reverse-coded prior to analysis, ensuring that higher scores consistently reflected more favorable usability perceptions across all items. The adjusted responses were subsequently classified into positive, neutral, and negative categories for descriptive presentation.

Table 2. The item-level distribution of SUS responses on adolescent girl's respondents

No	Statement	Response						Score
		Positive		Neutral		Negative		
		n	%	n	%	n	%	
1	I would use this application more frequently	53	86.9	8	13.1	0	0	8.0 ± 1.7
2	I found the application unnecessarily complex	55	90.2	5	8.2	1	1.6	8.1 ± 1.7
3	I thought the application was easy to use	54	88.5	7	11.5	0	0	8.6 ± 1.7
4	I think I would need the support of a technical person to be able to use this application	40	65.6	18	29.5	3	4.9	7.1 ± 2.2
5	I found the features in this application were well integrated	54	88.5	7	11.5	0	0	8.0 ± 1.5

6	I thought there was too much inconsistency in this application	49	80.3	7	11.5	5	8.2	7.5 ± 2.4
7	I believe most people would learn to use this application very quickly	57	93.4	2	3.3	2	3.3	8.5 ± 1.8
8	I found the application cumbersome to use	59	96.7	2	3.3	0	0	8.5 ± 1.4
9	I felt very confident using this application	53	86.9	7	11.5	1	1.6	8.1 ± 1.8
10	I needed to learn many things before I could get going with this application	30	49.2	17	27.9	14	23.0	5.9 ± 2.7
	Total Response	504	82.6	80	13.1	26	4.3	
	Total SUS Score							78 ± 12.7

DISCUSSION

Interpretation of Key Findings

The HemoGirl mobile application demonstrated good usability and user acceptance among adolescent girls, as reflected by the mean SUS score of 78. This score indicates that participants generally perceived the application as easy to use, understandable, and acceptable for its intended purpose. Observational findings further supported this result, as most participants were able to complete the assigned tasks with minimal assistance during the usability testing session. Taken together, these findings suggest that HemoGirl has achieved an important prerequisite for digital health interventions, namely user acceptability and functional usability. The simple and intuitive dashboard structure, combined with visually clear layouts, supported efficient access to application features. These design elements are particularly important for adolescent users, for whom visual appeal and ease of navigation are strongly associated with continued application use (24,25). The favorable usability outcome may be attributable to the integration of several user-centered features, including self-recording of IFA tablet consumption, nutritional status assessment, educational videos, and menstrual cycle tracking. These features were designed based on the Health Belief Model and Self-Regulation Theory, which emphasize the importance of self-monitoring, cues to action, and increased awareness in supporting preventive health behaviors (19,20). The positive user response therefore suggests that the application design was generally aligned with the needs and preferences of adolescent users.

However, the findings should be interpreted within the scope of the study objectives. A high SUS score indicates that users found the application acceptable and relatively easy to operate, but it does not demonstrate that the application improved anemia-related knowledge, increased adherence to IFA supplementation, changed dietary practices, or produced measurable health benefits. The present study evaluated usability rather than intervention effectiveness. Consequently, the findings should be regarded as preliminary evidence supporting the feasibility of HemoGirl as a digital platform for anemia education and monitoring, while further longitudinal and experimental studies are required to determine its behavioral and clinical impact.

Another important consideration concerns the reliance on self-monitoring and self-reported data within several application features. Information regarding IFA tablet consumption, anthropometric measurements, and menstrual history is entered directly by users and may therefore be subject to recall bias, social desirability bias, measurement inaccuracies, or incomplete reporting. While these functions may facilitate routine monitoring, the validity and reliability of user-generated data remain important considerations, particularly if the application is implemented to support school-based or health service monitoring programs. Future studies should therefore evaluate data quality and explore mechanisms to strengthen the accuracy and verification of self-reported information.

Comparison with Previous Studies

Prior studies have reported that applications incorporating self-monitoring features, such as dietary or supplement intake recording, achieve higher usability and engagement scores due to their relevance to users' daily routines (26). Similar to earlier anemia-related mHealth interventions, the inclusion of short educational videos in HemoGirl aligns with evidence showing that multimedia-based learning improves comprehension and retention of health information among adolescents (27). The findings of this study are consistent with previous research demonstrating that mHealth applications can effectively support health education and behavior monitoring among adolescents (28,29)

While previous mHealth interventions have demonstrated the potential of mobile applications to support health education and promote healthy behaviors among adolescents, HemoGirl offers several distinctive features that extend beyond conventional information delivery (30,31). Most existing anemia- or nutrition-related applications primarily focus on educational content, whereas HemoGirl integrates education with self-monitoring, behavioral support, and institutional monitoring within a single platform. Specifically, the application combines anemia education, IFA intake recording, nutritional status assessment based on BMI-for-age z-scores, and menstrual cycle tracking, enabling users to monitor multiple factors associated with anemia risk. In addition, HemoGirl incorporates a role-based monitoring system that allows teachers and health workers to access adherence reports, thereby strengthening accountability and facilitating coordination between schools and health services. This integration distinguishes HemoGirl from previously reported interventions and aligns with the implementation needs of Indonesia's school-based IFA supplementation program. Rather than functioning solely as an educational tool, the application was designed to support both individual self-management and program monitoring, potentially enhancing the practicality and scalability of digital health promotion initiatives targeting adolescent anemia prevention.

Limitations and Cautions

Several limitations should be acknowledged. First, the study was conducted in a single institution with a relatively small and homogeneous sample of adolescent girls aged 17–19 years, which may limit the generalizability of the findings to other adolescent populations and settings. Second, usability was evaluated only during a short-term supervised session; therefore, the findings do not reflect long-term engagement, continued application use, or sustained adherence to iron and folic acid supplementation. Third, several application features rely on self-reported data, including supplement intake, anthropometric measurements, and menstrual records, which may be subject to reporting and measurement bias. Although HemoGirl was developed for adolescent girls, teachers, and health workers, usability testing was limited to adolescent users. Therefore, the usability and acceptability of features intended for teachers and health workers remain to be evaluated in future studies. Finally, this study focused exclusively on usability and user acceptance and did not assess behavioral or clinical outcomes, such as anemia knowledge, supplementation adherence, dietary practices, hemoglobin levels, or anemia prevalence. Therefore, the findings should be interpreted as evidence of preliminary usability rather than application effectiveness.

Recommendations for Future Research

Future studies should evaluate the effectiveness of HemoGirl through longitudinal and experimental designs to assess its impact on anemia-related outcomes, including hemoglobin levels, dietary practices, and sustained adherence to IFA supplementation. Further research is also recommended to explore integration of the application into school-based health programs and to assess the role of teachers, parents, and health workers in supporting its implementation. Expanding the application to include automated data synchronization with health information systems may further enhance its utility for public health monitoring.

CONCLUSION

This study investigated the development and usability of the HemoGirl mobile application as a digital health promotion tool for anemia education and monitoring among adolescent girls and aimed to assess its user acceptance through usability testing. The findings demonstrated that the application achieved a high level of usability, with a mean SUS score of 78, indicating that the system was easy to use and well accepted by users. Notably, the integration of anemia educational content, digital self-recording of iron–folic acid (IFA) intake, nutritional status assessment

based on BMI-for-age Z-scores, menstrual tracking, and role-based monitoring functions for teachers and health workers represents a comprehensive and context-specific approach to anemia prevention in school settings. These findings suggest that HemoGirl is a promising prototype with acceptable usability and user acceptance, supporting its feasibility for further development and implementation testing. However, the present study assessed usability only and did not evaluate behavioral, educational, or clinical outcomes.

AUTHOR'S CONTRIBUTION STATEMENT

AR was responsible for conceptualization, methodology, formal analysis, data curation, preparation of the original manuscript draft, and manuscript revision. HR contributed to conceptualization, supervision, and critical review of the manuscript. DB contributed to investigation, resource acquisition, and manuscript review. IH contributed to software development, methodology, validation, and manuscript review. All authors reviewed and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest related to this study. The authors have no financial, personal, or institutional relationships that could have inappropriately influenced the conduct, analysis, or reporting of the research. This declaration is made to ensure transparency and to uphold the integrity, credibility, and objectivity of the study.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that AI-assisted technologies were used solely to improve language quality and clarity during manuscript preparation. These tools did not influence the study design, data analysis, or interpretation of results. All content and conclusions remain the sole responsibility of the authors.

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