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Development of an Android-Based Mobile Application and Digital Book through the ADDIE Model for Early Detection and Stunting Prevention Education

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ABSTRACT

Introduction: Stunting remains a major nutritional problem in Indonesia that affects the quality of human resources in the future. Adolescent girls play an important role in preventing stunting, but their nutritional literacy levels are still low. This study aims to develop an Android-based mobile application and digital book as educational media for early detection and prevention of stunting in adolescent girls.
Methods: The research was conducted in the city of Jambi in 2025 using the Research and Development (R&D) method through the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The research subjects were 20 adolescent girls selected through purposive sampling. Data were collected through questionnaires, interviews, observations, and tests.
Results: The needs analysis revealed substantial gaps in adolescents' understanding of nutrition and hematologic health, particularly concerning the interrelationship between anemia, hemoglobin status, and stunting risk. These findings underscored the necessity for accessible, technology-based learning tools tailored to adolescent users. Consequently, a mobile application and companion digital book were developed to integrate early detection features such as hemoglobin and body mass index assessments with interactive nutrition education. Expert evaluations confirmed the high feasibility and content validity of these media, while preliminary trials demonstrated their user-friendliness, contextual relevance, and potential to enhance adolescents' engagement and comprehension in stunting prevention.
Conclusion: The mobile application and digital book developed are proven to be suitable for the needs, feasible to use, and have the potential to increase the knowledge and awareness of adolescent girls in preventing stunting. This technology-based intervention can be a strategic innovation in supporting the program to accelerate the reduction of stunting in Indonesia.

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INTRODUCTION

Stunting remains a serious public health problem in Indonesia. Data shows that this condition not only hinders children's physical growth, but also affects brain development, intelligence, immune system, and future economic productivity. Stunting prevention must be carried out from adolescence, especially among adolescent girls, as they are future mothers who will determine the quality of the next generation(1,2). Low nutritional literacy among adolescent girls is one of the risk factors that can exacerbate stunting. A preliminary survey in Jambi City showed that 70% of adolescent girls were unaware of stunting, while 75% did not understand that anemia can increase the risk of stunting(3,4). This condition is consistent with findings from previous studies showing limited nutritional literacy among adolescents in Indonesia. Viewed within a broader theoretical perspective, this pattern also aligns with behavioral science concepts, particularly the Health Belief Model (HBM), which posits that health behavior is determined by an individual's perception of vulnerability, perceived benefits, and self-efficacy. According to Notoatmodjo, low health literacy and weak perceived susceptibility can reduce one's motivation to take preventive action, including in nutritional and stunting prevention contexts(5). Therefore, the lack of understanding among Indonesian adolescents may reflect not only informational gaps but also motivational barriers, underscoring the need for integrated, technology-based educational interventions that enhance awareness, engagement, and behavioral change.

Anemia in adolescent girls has serious consequences, not only for their current health but also for the risk of giving birth to low birth weight (LBW) babies who are potentially stunted. Therefore, educational interventions and early detection of adolescent nutritional status are important steps that must be taken immediately to break the cycle of stunting across generations(4,6). With the development of technology, mobile application-based digital media (mHealth) has begun to be utilized in health programs, including stunting prevention. This application is considered capable of providing faster, interactive access to information that is in line with the characteristics of the younger generation who are familiar with gadgets. Studies show that the use of Android-based nutrition education applications has been proven effective in increasing adolescents' knowledge about stunting prevention(3,7,8).

In addition to applications, digital books are also a relevant educational medium for adolescents. Digital books can present health information in a concise, visual, and easy-to-understand manner. Surveys show that 95% of adolescent girls say they need digital books as practical guides for preventing stunting. This reinforces the urgency of developing educational media that suits the needs and preferences of adolescents. Previous research shows that media-based educational interventions, both digital and print, can improve adolescents' knowledge and attitudes about balanced nutrition. For example, research using the flip chart method has been shown to significantly improve adolescents' nutrition knowledge scores(1). However, digital media has advantages in terms of interactivity and reach.

Therefore, this study explicitly aims to design, develop, and validate an Android-based mobile application and a companion digital book as integrated educational media for the early detection and prevention of stunting among adolescent girls using the ADDIE framework.

METHOD

This study employs a clear and systematic approach to ensure the reliability and validity of the findings. Below are the components of the methodology:

Research Type

This study employed a Research and Development (R&D) design using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The R&D approach was chosen to produce an Android-based early detection application and a digital book as educational media for preventing stunting among adolescent girls.

Population and Sample/Informants

The study population comprised adolescent girls aged 15–19 years in Jambi City, Indonesia. Sampling was conducted purposively to recruit participants who met the inclusion criteria: (1) being an adolescent girl residing in Jambi City, (2) owning a smartphone with Android OS, and (3) providing informed consent. The initial needs assessment involved 20 adolescent girls to identify baseline knowledge of anemia, nutrition, and stunting. These participants were not part of the subsequent expert validation phase but were re-engaged in the limited user testing

stage to evaluate the usability and relevance of the developed products. Additional participants, including nutritionists, health educators, and IT developers, were separately recruited for expert validation and media assessment. This sequential design ensured methodological clarity, allowing distinct groups to contribute to the analysis, validation, and implementation phases of the research.

Research Location

The research was conducted in Jambi City, Indonesia, across schools, youth health posts, and community-based adolescent groups.

Instrumentation or Tools

To ensure methodological rigor, all instruments underwent validity and reliability testing prior to data collection. Content validity was assessed by three experts in nutrition education, instructional media, and public health, who evaluated each item's relevance, clarity, and representativeness using a four-point Likert scale. The Item-Content Validity Index (I-CVI) ranged from 0.85 to 1.00, indicating strong content validity. Reliability testing of the questionnaire items produced a Cronbach's alpha coefficient of 0.87, confirming good internal consistency. These procedures ensured that the instruments used, including questionnaires, interview guides, and expert validation sheets, were both scientifically sound and contextually appropriate for measuring adolescents' knowledge, attitudes, and behaviors related to stunting prevention.

Data Collection Procedures

Data collection was carried out in sequential phases following the ADDIE framework to ensure a systematic development process. During the analysis stage, a needs assessment was conducted through surveys, interviews, and observations with adolescent girls to identify their baseline knowledge and requirements. The design stage involved drafting the storyboard, application features, and educational content in close collaboration with experts to ensure both accuracy and relevance. In the development stage, the prototype was created and subsequently validated by experts such as nutritionists and media specialists, as well as by practitioners including midwives and teachers, to assess its scientific and practical reliability. The implementation stage consisted of pilot testing with small groups of adolescent girls to evaluate the usability, practicality, and comprehensibility of the application and digital book. Finally, the evaluation stage encompassed both formative assessments, carried out individually and in small groups, and summative evaluations through larger field trials, using pre- and post-tests, interviews, and Likert-scale surveys to measure effectiveness and impact.

Data Analysis

Data were analyzed using both descriptive and inferential statistics. Prior to hypothesis testing, data normality was examined using the Shapiro–Wilk test to determine the suitability of parametric analysis. Since the data met the assumption of normal distribution ($p > 0.05$), a paired t-test was applied to compare pre-test and post-test knowledge scores of adolescent girls before and after the intervention. In addition, effect size was calculated using Cohen's *d* to assess the magnitude of the intervention's impact beyond statistical significance. The interpretation of results followed conventional thresholds, where *d* values of 0.2, 0.5, and 0.8 represented small, medium, and large effects, respectively.

Ethical Approval

This research obtained ethical clearance from the Health Research Ethics Committee, Poltekkes Kemenkes Jambi (Approval No: LB.02.06/2/120.1/2024), ensuring compliance with the principles of autonomy, beneficence, non-maleficence, and justice. Written informed consent was obtained from all participants (and parental consent for minors) prior to participation.

RESULTS

Analysis Stage (Needs Analysis)

The initial stage was conducted to determine the level of nutrition literacy, understanding of stunting, and educational media needs among adolescent girls in Jambi City.

Table 1. Thematic Summary of Needs Analysis among Adolescent Girls

Thematic Indicator	Specific Aspects Assessed	Yes (%)	No(%)
Knowledge and Awareness	Understanding of stunting and its prevention	30.0	70.0
	Understanding of the impact of anemia on stunting	25.0	75.0
	Ability to calculate Body Mass Index (BMI)	25.0	75.0
Health Behaviors	Ever checked hemoglobin (Hb) level	20.0	80.0
	Regular consumption of iron tablets	20.0	80.0
	Physical activity ≥30 minutes per day	35.0	65.0
Digital Learning Needs and Preferences	Perceiving current educational media as sufficient	15.0	85.0
	Need for an Android-based application for stunting prevention	90.0	10.0
	Need for a digital book as a preventive guide	95.0	5.0
	Willingness to regularly use digital media developed	85.0	15.0

Thematic analysis of the needs assessment revealed that adolescent girls demonstrated limited knowledge and awareness regarding stunting, anemia, and nutritional indicators, accompanied by low engagement in preventive health behaviors such as hemoglobin monitoring, iron supplementation, and regular physical activity. However, their strong preference for digital learning platforms reflected by high interest in Android-based applications and digital guidebooks indicates a high level of technological readiness and motivation for interactive, accessible education. This contrast between low nutritional literacy and high digital engagement suggests that integrating technology-based educational media could effectively bridge informational and behavioral gaps, fostering greater awareness and proactive stunting prevention among adolescents.

Design Stage

The design stage is carried out after the needs analysis to formulate the form of the application and digital book that suits the characteristics of adolescent girls. At this stage, the content and features of the application are designed to fulfill two main functions, namely simple screening (detection of nutritional status through Hb, BMI, and physical activity) and digital education (interactive material on stunting, anemia, and balanced nutrition). The application design is created with a simple interface, easy-to-understand navigation, and communicative language so that it can be accessed by adolescents with varying levels of literacy. Meanwhile, the digital book is compiled in a concise and visually appealing format, complete with illustrations and practical examples relevant to the daily lives of adolescents.

Table 2. Feature Design of the Early Detection Application for Stunting Prevention and Companion Digital Book

Menu/Features	Data Input	Output/Information	Additional Education
Teen Hemoglobin	Hemoglobin Level (g/dL)	Anemia/normal category	The impact of anemia and how to prevent it
Teen Body Mass Index	Weight (kilograms), Height (centimeters)	Nutritional status (BMI)	The relationship between adolescent nutrition and stunting
Physical Activity	Type & duration of activity	PAL score (mild–severe)	The role of physical activity in health
Educational Materials		Information on stunting prevention	The First 1000 Days of Life, anemia, balanced nutrition
Summary of Results	Hemoglobin Data, Body Mass Index, Activity	Summary of detection results	Personalized recommendations

The product design combines simple screening functions with digital education, so that adolescents not only know their nutritional status but also receive recommendations for preventive measures.

Development Stage (Product Development)

The product was developed using Android Studio (application) and interactive PDF digital book format (digital book). After the prototype was completed, it was validated by subject matter experts and media experts.

Table 3. Expert Validation Results

Validator	Aspects Evaluated	Average Score (%)	Category
Subject Matter Expert	Content, language, relevance, features	87.5	Highly Recommended
Media Expert	Appearance, navigation, interaction	85.0	Highly Recommended

Expert validation confirms that the product is highly suitable for use. Suggested improvements include adding a glossary of medical terms, presenting case studies, enhancing visual illustrations, and strengthening motivational features.

Implementation Stage

The product was tested on 20 adolescent girls. Respondents were asked to try all the features of the application (Hb, BMI, physical activity, education) and open the digital book.

Table 4. Limited Trial Assessment

Aspects Evaluated	Score (1–4)	Category
Ease of use	3.7	Very Good
Visual appearance	3.5	Very Good
Clarity of information	3.6	Very Good
Benefits to knowledge	3.8	Very Good
Overall average	3.65	Very Good

Limited trials show that the application and digital book are considered user friendly, informative, and useful in improving understanding of stunting prevention.

Evaluation Stage

The evaluation was conducted using a Likert scale questionnaire. The results show that the application and digital book are effective in improving nutrition literacy, awareness, and skills among adolescents in early detection of stunting risk factors.

Table 5. Impact of Educational Media Evaluation

Knowledge Change Indicators	Before (%)	After (%)
Knowing the definition of stunting	30.0	90.0
Understanding the link between anemia and stunting	25.0	85.0
Knowing how to calculate BMI	25.0	80.0
Understanding the importance of iron tablets and physical activity	20.0	75.0

There was a significant increase in adolescents' knowledge after using the app and digital books. The products proved to be effective educational media for the prevention of stunting from adolescence onwards. This aligns with previous studies demonstrating that digital-based interventions can enhance adolescents' awareness of nutrition and reproductive health.

A paired t-test analysis was conducted to determine the difference in the knowledge level of adolescent girls before and after using the early detection application and digital book on stunting prevention. The analysis results showed a significant increase in knowledge scores after the intervention. The pre-test mean score was 56.40 ± 8.21, while the post-test mean score increased to 82.75 ± 6.94. The paired t-test results produced a t-value of 12.47, with p

< 0.001, indicating a significant difference between the scores before and after the intervention. This shows that the use of the application and digital book is effective in increasing adolescent girls' knowledge about anemia, balanced nutrition, physical activity, and stunting prevention.

Table 6. Results of the T-test for Knowledge of Adolescent Girls Before and After Intervention

Variable	Mean±SD	t-value	p-value	Description
Pretest	56.40±8.21	12.47	0.001	Significant (p<0.001)
Posttest	82.75±6.94			

These results suggest that the digital-based educational media developed in this study had a significant effect on improving adolescent girls' knowledge of stunting prevention.

DISCUSSION

The following subsections present a detailed interpretation of the study findings, their comparison with previous research, as well as the strengths, limitations, and future directions related to the development of an early detection application model for adolescent girls in the prevention of stunting

Interpretation of Key Findings

The results of this study indicate that most adolescent girls still exhibit low levels of nutritional literacy, particularly regarding the relationship between anemia, nutritional status, and stunting risk. Beyond its practical implications, this finding conceptually reinforces the relevance of the Health Belief Model (HBM) and the Digital Health Literacy Theory (DHLI) as theoretical underpinnings for the intervention. The developed Android-based application and digital book, designed through the ADDIE framework, operationalize the HBM constructs of perceived susceptibility, benefits, and self-efficacy by enabling adolescents to monitor their hemoglobin and body mass index while accessing interactive nutrition education. Simultaneously, the intervention advances DHLI principles by enhancing users' ability to locate, understand, and apply digital health information in everyday life. By merging these theoretical perspectives into a single model of early detection and digital education, this study offers a distinctive conceptual contribution bridging health behavior theory and digital literacy frameworks to promote sustainable engagement and behavioral change in stunting prevention among adolescents. This is in line with the research by Handayani et al. (2024) which shows the low nutritional knowledge of adolescent girls in Sleman after the flip chart intervention (1), as well as the findings of Antikasari et al. (2023) proving the effectiveness of Android applications in increasing knowledge about stunting (3). Collectively, these results highlight that digital interventions aligned with adolescents' technological preferences and interactive learning styles are not only more engaging but also more effective in translating knowledge into preventive health behaviors.

Furthermore, various studies show that interactive educational media can help improve adolescent girls' understanding of nutrition. Education using flipcharts has been proven to increase adolescents' knowledge and attitudes in preventing stunting, while Android-based digital pocket books are more effective than traditional methods in strengthening nutritional understanding from the preconception period. These results confirm that digital interventions and engaging learning media can bridge the nutrition information gap, particularly in efforts to prevent anemia and stunting across generations (9,10).

The role of digital applications in stunting prevention is further emphasized by research by Lubis & Mufdlilah (2024), which demonstrated the feasibility of mHealth applications to support stunting prevention (11). mHealth applications have been shown to bridge the gap in access to health information, especially among adolescents(12–14). Furthermore, research by Setyawati & Kurniadi (2022) on the Giziku Baik application also demonstrated the effectiveness of self-recording of nutritional status in adolescents, making it easier for them to continuously monitor their health (4). Such applications not only provide information but also educate adolescents to be more aware of their own nutritional status.

In addition to apps, other digital media, such as educational videos, have also proven effective in improving understanding of nutrition and health. Suiraoka et al. (2024) developed a stunting prevention video that improved adolescents' understanding of balanced nutrition (15). Videos were considered more engaging because they presented

information visually and narratively, aligning with the learning preferences of the younger generation. This finding is supported by Kurniatin et al. (2024), who demonstrated the effectiveness of WhatsApp modules and videos on adolescents' nutritional knowledge (16). Thus, the use of audiovisual media plays a crucial role in creating a more engaging and memorable learning experience for adolescents.

Many Android-based applications have also been developed for different target groups, including pregnant women, breastfeeding mothers, and prospective brides. For example, the Bocesting application has been shown to improve maternal nutritional behavior and the nutritional status of toddlers (17,18). This behavioral improvement is important because maternal nutritional interventions have a direct impact on child growth. The SusCatinTing application is also effective in increasing prospective brides' knowledge regarding stunting prevention, thus preparing the next generation from the pre-pregnancy period (19). These findings demonstrate that digital innovation can be applied across life stages, from adolescence to young adulthood.

Comparison with Previous Studies

These findings are consistent with Handayani et al. (2024), who reported low nutrition knowledge among adolescent girls in Sleman after flip chart interventions (1), as well as Antikasari et al. (2023), who demonstrated the effectiveness of Android applications in increasing stunting-related knowledge (3). Similarly, previous studies confirmed the feasibility of mHealth applications for stunting prevention and highlighted their role in overcoming barriers to information access among adolescents (20–22). Other studies also support the potential of digital innovations for different target groups, such as pregnant women, brides-to-be, and mothers of young children (18,19).

The evidence also aligns with Suiraoka et al. (2024) and Kurniatin et al. (2024), who showed the effectiveness of audiovisual interventions (15,16), and with Setyawati & Kurniadi (2022), who validated self-monitoring nutrition applications (4). In addition, Rifqi (2024) emphasized the importance of UI/UX design in digital media effectiveness (23), while Prasetyani et al. (2024) demonstrated the role of digital tools in empowering community health workers (24). These converging findings indicate that digital-based interventions are not only effective but also adaptable across different contexts and populations, thereby supporting the broader goal of stunting prevention.

Conceptual Contribution

This study contributes conceptually by integrating behavioral science and digital literacy frameworks into a unified model of adolescent health education. Drawing upon the Health Belief Model (HBM) and the Digital Health Literacy Theory (DHLI), the intervention advances a multidimensional understanding of how perceived vulnerability, motivation, and digital competency interact to influence preventive behaviors. The Android-based application and digital book developed through the ADDIE model function not merely as educational tools but as operational embodiments of these theoretical constructs, facilitating cognitive engagement, behavioral reinforcement, and self-regulated health monitoring. This synthesis represents a novel theoretical contribution to adolescent nutrition research, demonstrating how technology-enhanced learning can bridge the gap between health literacy theory and practical stunting prevention strategies within a culturally relevant digital ecosystem.

Limitations and Cautions

Although this study confirms the role of digital media in improving nutrition literacy among adolescents, several limitations should be considered. First, the reliance on previously published studies may limit the contextual depth of interpretation because variations in methodology, intervention design, and cultural settings could influence the outcomes. Second, most of the cited studies were conducted in specific regions of Indonesia, which may restrict the generalizability of the findings to other populations with different socio-cultural and technological characteristics. Third, many of the interventions assessed short-term knowledge gains, while long-term behavioral changes and their direct impact on stunting prevalence remain less explored. Finally, differences in application design, delivery platforms, and user engagement may affect the comparability of results across studies.

Although the use of digital media has been shown to improve adolescent nutritional literacy, most studies assess short-term outcomes and have not demonstrated sustained behavioral changes. For example, a study in Semarang showed that digital interventions only slightly improved nutritional attitudes, but the increase in knowledge was not significant within the short intervention period (25). Furthermore, a systematic review of mobile applications

for mothers of stunted children found that although nutritional literacy improved, most studies did not evaluate whether these changes actually resulted in healthy eating habits or reduced stunting prevalence (20). This confirms that evidence regarding the long-term effects of digital interventions is still limited and requires further research with more robust designs.

Similar innovations have emerged through the E-Supreme app, which has been shown to improve adolescent knowledge (26), and the EDBUSUI app, which supports stunting prevention in breastfeeding mothers (27). Both demonstrate variations in the use of digital apps according to target needs, both for adolescent nutrition education and breastfeeding support. Thus, app innovations can be tailored specifically to target users to increase intervention effectiveness. Not only apps, but digital book-based interventions have also proven beneficial. Resmiati (2022) showed that the combination of a pocket book and an Android app increased adolescents' positive attitudes toward stunting (28). Digital books offer information in a simpler and more visual format, making it easier to understand. Meanwhile, Werdani et al. (2024) emphasized the importance of peer educators in adolescent education (29). Peer education strategies are considered effective because adolescents are more receptive to information from their peers than from adults.

Several other studies have also reinforced the importance of nutritional literacy through digital applications. Research by Marlinawati et al. (2023) demonstrated the effectiveness of technology-based media in adolescent education (30), proving that technology-based interventions are more adaptive to the needs of the younger generation. Meanwhile, Mokoagow et al. (2024) identified the strategic role of adolescents in the stunting prevention cycle (31). These findings confirm that adolescents are not only beneficiaries but also agents of change in stunting prevention efforts.

Recommendations for Future Research

Future studies should address these limitations by employing longitudinal designs to examine the sustainability of behavioral changes and their direct impact on stunting reduction. Cross-regional and cross-cultural studies would help assess the adaptability and effectiveness of digital interventions in diverse contexts. Research should also investigate the role of user experience (UX), gamification, and personalized feedback in enhancing adolescent engagement with digital platforms. Furthermore, integrating digital interventions with existing school-based health programs and community health services could strengthen their reach and effectiveness. Expanding the scope of digital innovations to involve families and peers as part of a supportive environment will also be critical in ensuring sustainable impacts on adolescent nutrition literacy and stunting prevention.

CONCLUSION

This study successfully developed a mobile application and digital book as educational media for early detection and prevention of stunting in adolescent girls using the ADDIE-based research and development (R&D) model. The results of the needs analysis showed that the majority of adolescent girls still had low knowledge about stunting and anemia, but had a high interest in digital-based educational media. The validation process by subject matter and media experts placed the product in the highly feasible category, while limited trials showed that the application and digital book were easy to use, interesting, and useful in improving adolescents' understanding of balanced nutrition and stunting prevention. Thus, this application and digital book have the potential to be a strategic innovation in supporting the program to accelerate stunting reduction in Indonesia. In the future, this product needs to be refined by adding interactive features such as reminders to consume Iron-Folic Acid Tablets and a discussion forum for adolescents, as well as being tested on a wider scale to obtain more comprehensive results. Additionally, collaboration between the government, health workers, and educational institutions is crucial so that this app and digital book can be optimally integrated into adolescent health programs. Further research with a longitudinal design is also needed to assess the long-term impact of using this digital educational media on changes in adolescent nutritional behavior and stunting prevention in the next generation.

AUTHOR'S CONTRIBUTION STATEMENT

All authors contributed substantially to the conception and design of this study. Lia Artika Sari was primarily responsible for conceptualizing the research framework, developing the application model, and drafting the initial

manuscript. Enny Susilawati contributed to data collection, methodology design, and critical revision of the manuscript for important intellectual content. Diniyati was involved in data analysis, interpretation of findings, and refinement of the final draft. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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

The authors declare that they used ChatGPT to assist in improving the language, grammar, and overall readability of the manuscript. The tool was not used for generating, analyzing, or interpreting the research data. After using this tool, the authors carefully reviewed, edited, and validated the content to ensure accuracy, originality, and compliance with academic standards. The authors take full responsibility for all parts of the manuscript.

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