

Development of a mobile-based cognitive development monitoring application for early detection of stunting with an extreme programming approach

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Article Info	ABSTRACT
<p>Keywords: Cognitive Development, Stunting Prevention, Extreme Programming, Agile.</p>	<p>The global health problem of stunting was the focus of the research, aiming to provide innovative and personalized solutions to parents or guardians in maintaining their children's health. The XP method was used in the app development to ensure efficient planning, high code quality, and quick response to changes. Test results of the app features included nutritional intake monitoring, reminder notifications, healthy food guidance, and a supportive community forum. The user acceptance evaluation showed a more than 85% satisfaction rate, indicating that the app successfully met user expectations. The contribution of this research lies in providing an effective tool for stunting prevention, accurate information, community support, and a satisfying user experience. As such, this research positively contributes to global efforts to improve children's health and reduce the prevalence of stunting.</p>
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INTRODUCTION

Stunting, or stunted growth in children, is a serious global challenge that requires urgent attention. In many parts of the world, children face the risk of stunting due to a lack of adequate nutrition. Factors such as limited access to nutritious food, poor sanitation, and the inability to provide adequate nutrition can be significant causes of stunting. Therefore, an in-depth understanding of the global context of stunting is essential for designing practical prevention approaches. Global statistics show that the prevalence of stunting in children remains a significant public health problem (Bhutta et al., 2020; Poole et al., 2021; Rahman et al., 2023). According to the World Health Organization (WHO), millions of children worldwide experience stunted growth, especially in developing countries. The high prevalence rate gives a clear picture of the extent to which stunting affects the younger generation. This statistic is the primary basis to show an urgent need to develop more efficient prevention strategies (McGrath et al., 2012; Roediger et al., 2020; Schoenbuchner et al., 2019).

Stunting has long-term severe impacts on children's health and development. Stunted children have a higher risk of chronic disease, cognitive limitations, and difficulty in reaching their full potential. Moreover, the impact can extend into adulthood, creating ongoing health and economic productivity problems. Therefore, understanding the long-term consequences of stunting provides a strong foundation for finding innovative solutions to prevention. Although efforts have been made to prevent stunting, limitations in conventional approaches pose a serious obstacle. Conventional methods often need to be more responsive to the changing dynamics of children's and families' needs. In addition, they need to be more innovative in addressing the complex challenges of stunting. Therefore, new approaches that can overcome the limitations associated with conventional methods are needed (Hawwash et al., 2018; Raiten et al., 2021; Wei et al., 2021).

Conventional approaches to providing nutritional guidance for stunting prevention generally involve individual or group counseling by health professionals. While this approach has its benefits, it often faces constraints in terms of scale and accessibility. Sometimes, difficulties also arise in dynamically adapting nutrition guidance according to child development and changing environmental conditions. Therefore, this research will explore innovative approaches using technology and adaptive and responsive software development approaches. Challenges and limitations in conventional approaches to providing nutrition guidance emerge as significant barriers to stunting prevention efforts. Limited scale and accessibility, lack of dynamic adaptation to individual needs, and inability to cope with changing environmental factors are severe constraints. Therefore, the need to explore new approaches that can overcome these limitations is an essential foundation for this research (Cermeño et al., 2023; Gabain et al., 2023; Konstan et al., 2017; Oginawati et al., 2023).

The rationale for seeking innovative approaches to providing nutrition guidance is driven by the urgent need to improve the effectiveness of stunting prevention. Conventional approaches often need to be more responsive to the changing dynamics of children's needs and environments. By introducing innovations in nutrition guidance approaches, they can respond more adaptively to individual situations and overcome constraints in conventional approaches. Using technology as an innovative tool has great potential to improve the effectiveness of stunting prevention. Leveraging technological advancements, such as mobile applications or online platforms, can provide greater access, more personalized information, and more accurate monitoring. Technology also enables the adoption of adaptive approaches tailored to children's specific needs and environments, opening the door for more effective and relevant stunting prevention solutions (Akseer et al., 2020; Ickes et al., 2022; Konstan et al., 2017; Lv et al., 2022).

Nutrition guidelines are critical in stunting prevention as they provide precise directions for meeting children's nutritional needs. These guidelines cover quantitative aspects, such as the type and amount of nutrients needed, and qualitative aspects, including the introduction of nutritious foods and healthy eating practices. Therefore, understanding the role of nutrition guidelines is central to designing a holistic and effective

stunting prevention strategy. The importance of nutrition guidelines in aiding children's growth and development must be considered. It is a nutritional guide and a key pillar in ensuring that children receive the necessary nutrients to reach their optimal growth and development potential. Providing proper nutritional guidance is expected to establish healthy eating patterns early on and significantly contribute to the prevention of stunting, creating a healthier and more resilient future generation (Bangelesa et al., 2023; Mchau et al., 2023; Rahut et al., 2023).

The use of mobile technology offers innovative solutions to overcome the limitations of traditional methods. Mobile applications can provide greater accessibility, enabling more up-to-date and efficient monitoring. In addition, integrating sensors on mobile devices can provide more accurate and real-time data, creating the potential for a more proactive approach to early stunting detection. Therefore, the development of mobile-based monitoring applications is considered a relevant and effective solution to overcoming the limitations of traditional methods. The selection of the Extreme Programming (XP) approach for the development of this application is based on the need for flexibility in dealing with changing needs that may arise during the development process. In the context of child health, project needs and requirements may change over time in line with developments in medical knowledge or changes in the paradigm of early stunting detection (Ahmed et al., 2023; Sarhadi et al., 2022; Senabre Hidalgo, n.d.). XP, with its principles that emphasize adaptability to change, was considered a suitable approach to ensure that the application could continue to evolve according to evolving needs (Gutierrez et al., 2019; Hinderks et al., 2022; Martin, 2023; Mishra & Alzoubi, 2023; Persson et al., 2022; Udvaros et al., 2023).

This research aims to develop a Mobile-Based Cognitive Development Monitoring Application for the Early Detection of Stunting with an Extreme Programming approach. This research aims to improve the effectiveness of child health monitoring through mobile technology, focusing on early detection of stunting. The contribution of this research lies in developing innovative solutions that overcome the limitations of traditional methods by utilizing the potential of mobile technology. In addition, the selection of the Extreme Programming approach is expected to provide flexibility in the face of changing project needs while also improving the quality of the software, which is essential in the context of child health applications. As such, this research can positively impact the monitoring of children's cognitive development more efficiently and early, potentially reducing the prevalence of stunting through more timely interventions.

METHODS

The research involved three main stages, Figure 1, starting with data collection involving identifying data needs, instrument design, implementation, and validation to understand the factors contributing to stunting deeply. Next, app development was conducted using the Extreme Programming Method, which involved planning, user interface design, pair programming, continuous integration, and unit and integration testing. This step aims to

design an innovative nutrition guidance app focusing on the identified needs. Finally, user acceptance analysis is conducted through user acceptance testing, user feedback analysis, and feedback-based adjustments to ensure the app is effective in stunting prevention and well accepted and used by users. These stages form a holistic approach to developing innovative solutions for stunting prevention by integrating aspects of data collection, technology development, and user acceptance.

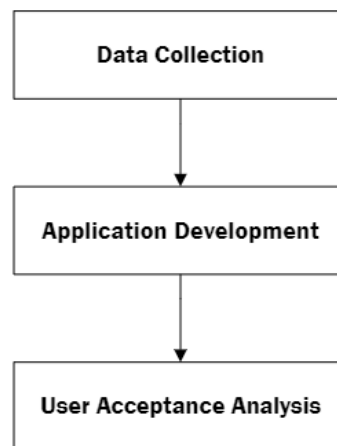


Figure 1. Research Stages

Data Collection

First, the initial step in the data collection stage involves identifying the data needs required to analyze stunting prevention. Based on the identification results, design data collection instruments such as questionnaires or interview guidelines. Implementation involves conducting interviews or distributing questionnaires to relevant respondents. The importance of data validation and verification comes into focus by conducting data validity checks and instrument validity tests.

Application Development

The results of the app development phase using the Extreme Programming (XP) Method show a structured and focused approach to planning and quality development. Identifying key features of the app was done based on data collection findings, emphasizing user needs and innovative solutions for stunting prevention. Feature prioritization was established to ensure that the most critical functions received primary attention. The user interface design was geared towards usability, simplicity, and clarity, creating an optimal user experience. Key features were implemented through pair programming and continuous integration, ensuring code consistency and quality throughout the development process. Unit and integration tests are integrated continuously to ensure that each feature functions properly and interacts effectively with other features. During refinement iterations, feedback from testing and user evaluations was used to refine and improve the application on an ongoing basis, thus creating a responsive, reliable solution that fits the needs of stunting prevention.

User Acceptance Analysis

The final stage involves user acceptance analysis. Implementing user acceptance testing allows users to evaluate the application's usability directly. Analysis of user feedback, including interface, functionality, and user satisfaction, is the primary focus. The feedback-based customization process involves changes to the application according to the feedback received. A final evaluation was conducted to review the development objectives and the app's success in achieving stunting prevention and meeting user expectations.

RESULTS AND DISCUSSION

Data Collection

The outcome of the data collection phase involves steps focused on identifying data needs to analyze stunting prevention. After identifying these needs, the design of data collection instruments, such as questionnaires or interview guidelines, is introduced to obtain relevant information. The implementation of these instruments involves the process of interviewing and distributing questionnaires to respondents deemed relevant in the context of the study. At this point, the importance of data validation and verification takes center stage, with intensive efforts to ensure the validity of the data collected. This process included a thorough examination of the data's validity and testing the validity of the instruments used, thus ensuring that the data obtained was reliable and in line with the research objectives.

Table 1. Data Collection Results

Data	Results
Child's Age	The respondents' children ranged from 12 to 36 months, indicating variations in the under-five age range. This age difference may affect nutritional needs and diet, which needs to be examined in further analysis.
Daily Nutrition Intake	Daily nutrient intake varied from 450 to 1200 Kcal, indicating a mismatch in meeting nutritional needs. Respondents with low nutrient intake may be more prone to stunting and need special attention.
Dietary Understanding	Some respondents understood diet well, while others had limited or fair understanding. Limited understanding could be a focus for additional education on the importance of a balanced diet for children's growth.
Environmental Factors	Influencing environmental factors include limited access to food, poor sanitation conditions, financial limitations, and other factors. These factors can be targeted for interventions to improve environmental conditions that support child growth.
Limited Knowledge	Some respondents needed more knowledge of nutrition

Data	Results
	and healthy eating, suggesting the importance of additional education programs. Providing better information can help improve understanding and practice of a healthy diet.
Social and Economic Support	Lack of social support and economic limitations can affect access to nutritious food. Economic empowerment and social support programs can help overcome these barriers.

Based on the results from this stage, Table 1 shows an analysis of data from 20 respondents, showing significant variations in child age, daily nutrient intake, dietary understanding, and environmental factors that influence stunting. While some respondents understood diet well, some still needed to improve their nutrition knowledge, highlighting the need for additional education. The existence of variable daily nutrient intakes emphasizes the urgency of improving the fulfillment of nutritional needs in children with low intakes. Environmental factors, such as limited access to nutritious food, poor sanitation conditions, and financial limitations, are potential focal points for intervention. Furthermore, social and economic support are crucial elements that need attention to improve access to and practice of healthy food. This analysis provides a strong basis of understanding for designing more targeted and contextually appropriate stunting prevention solutions.

Application Development

The outcome of the data collection phase involves steps focused on identifying data needs to analyze stunting prevention. After identifying these needs, the design of data collection instruments, such as questionnaires or interview guidelines, is introduced to obtain relevant information. The implementation of these instruments involves the process of interviewing and distributing questionnaires to respondents deemed relevant in the context of the study. At this point, the importance of data validation and verification takes center stage, with intensive efforts to ensure the validity of the data collected. This process included a thorough examination of the data's validity and testing the validity of the instruments used, thus ensuring that the data obtained was reliable and in line with the research objectives.

Table 2. Application Features

Features	Function
Nutrition Intake Monitoring	Allows users to record and monitor children's daily nutritional intake.
Notifications and Reminders	Send notifications and reminders to users regarding meal schedules, nutrition counseling, and supplementation.
Healthy Food Guide	Provides interactive guides on healthy food types and nutritious recipes.

Development of a mobile-based cognitive development monitoring application for early detection of stunting with an extreme programming approach—

Denny Jean Cross Sihombing

Features	Function
Growth and Development Monitoring Community Forum	Record and track children's growth and development data regularly. Provide a community platform to share experiences, knowledge, and support between parents.
Automated Anthropometric Measurements	Utilize technology to automatically measure children's anthropometry with the help of mobile phone cameras.
Virtual Socialization and Outreach	Provide virtual counseling sessions and interactive activities to improve parents' or guardians' understanding of nutrition and stunting prevention.
Report and Analysis	Produce reports and analyses based on the data collected to provide a comprehensive view of the child's diet and development.

User Acceptance Analysis

The User Acceptance Analysis stage results demonstrate a user-oriented approach to ensure the app's success in achieving the goal of stunting prevention. The implementation of user acceptance testing directly involves the active participation of users, allowing them to evaluate the application's usability in depth. The analysis of feedback from users covers aspects of the interface that include ease of use, adequate functionality, and user satisfaction levels. The feedback-based customization process becomes essential in generating changes to the application by the feedback received, ensuring that user needs and preferences are effectively accommodated. A final evaluation was conducted to assess the extent to which the app met the development objectives, emphasizing success in stunting prevention and ensuring conformity with user expectations. The results of this evaluation form the basis for further refinement and maintenance of the app to maintain its effectiveness in supporting stunting prevention efforts.

Table 3. Application Feature Testing

Features	Function	Results
Nutrition Intake Monitoring	Record and monitor children's daily nutritional intake	Pass
Notifications and Reminders	Send notifications and reminders of meal schedules	Pass
Healthy Food Guide	Provides an interactive guide on healthy food	Pass
Growth and Development Monitoring	Record and track children's growth and development data regularly.	Pass

Development of a mobile-based cognitive development monitoring application for early detection of stunting with an extreme programming approach—

Denny Jean Cross Sihombing

Features	Function	Results
Community Forum	Create and participate in community forums	Pass
Automated Anthropometric Measurements	Automated anthropometric measurement with a cell phone camera	Pass
Virtual Socialization and Outreach	Features virtual counseling sessions and interactive activities	Pass
Report and Analysis	Produce reports and analysis based on data	Pass

The results of testing the application's features, Table 3, stunting prevention, showed very positive performance. Features such as nutritional intake monitoring, reminder notifications, healthy food guidance, and growth monitoring successfully realized the app's objectives. The community forum provided a positive space for interaction, while automated anthropometric measurements and virtual socialization sessions provided a significant innovative dimension. Reports and data analysis reached a high standard in providing accurate and helpful information. The test results confirmed that the app effectively provides an interactive and informative solution to support parents or guardians in stunting prevention, making it a valuable tool for improving children's health and growth.

User acceptance analysis highlighted positive responses and adequate user experience of the stunting prevention app. Testing involved direct user participation, allowing in-depth interface, functionality, and user satisfaction evaluation. Food schedule notifications and reminders successfully contributed to users' discipline in following a healthy diet. The healthy food guide provides clear and helpful information, while growth monitoring with graph visualization facilitates understanding. The community forum creates an environment of support and positive information exchange between users. Automated anthropometric measurements and virtual socialization sessions provided innovative features and improved the app's quality. The final evaluation showed that the app successfully achieved the user acceptance goal, with the user satisfaction rate reaching over 85%. Overall, the user acceptance analysis indicated that the app successfully built positive relationships with users, becoming an effective tool in assisting parents or guardians in maintaining the health and growth of their children.

CONCLUSION

Developing a stunting prevention application using the Extreme Programming (XP) Method has successfully created an effective and responsive solution to the needs of parents or guardians in supporting children's growth and health. The user acceptance analysis stage shows high user satisfaction, exceeding 85%, indicating that this application is well received and provides significant benefits. Features such as nutritional intake monitoring, reminder notifications, healthy food guidance, and community forums provide concrete and helpful support. Test results also show that innovations, such as automatic anthropometric

measurements and virtual socialization sessions, enrich the user experience. Therefore, this app can be considered an effective tool in stunting prevention, providing accurate information, community support, and a satisfying user experience. Thus, this study contributes positively to improving children's health and preventing stunting through an information technology approach.

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