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# SmartNutri: An Android-Based Application to Improve Parental Nutrition Literacy and Growth Monitoring for Children Under Five Years Old

Nur Alinuddin Kaharu*[1], Wildan[2]
[1,2]*Information Systems, Sekolah Tinggi Manajemen Informatika & Komputer Adhi Guna, Palu, 94111, Indonesia*
*Corresponding Author: alinuddinkaharu@gmail.com

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**ABSTRACT**

Stunting and undernutrition among children under five years old remain major public health challenges in Indonesia, particularly in developing regions like Palu City. These issues are often exacerbated by low parental nutrition literacy and limited access to real-time growth monitoring. This study aims to develop and evaluate SmartNutri, an Android-based nutrition education application designed to enhance parental knowledge and facilitate independent growth monitoring. The application integrates a nutrition calculator, growth monitoring dashboard, and menu recommendations aligned with Indonesian Ministry of Health Regulation No. 2 of 2020. A mixed-method approach was employed, involving 50 parents selected through purposive sampling and 10 community health workers (Posyandu cadres). Functional testing across 25 scenarios demonstrated that the system operated correctly on multiple devices, while the System Usability Scale (SUS) evaluation yielded an average score of 84.6 ("Excellent"). Furthermore, parental nutrition knowledge significantly increased from 58.4 ± 10.2 to 81.7 ± 8.9 ($p < 0.001$) after four weeks of use. SmartNutri successfully bridges the gap between nutrition literacy and behavioral practice, providing a scalable and user-friendly tool to support early childhood nutrition.

**Keyword:** *Nutrition Literacy, Stunting, Android Application, Growth Monitoring, SmartNutri*

**ABSTRAK**

Stunting dan gizi kurang pada anak di bawah usia lima tahun masih menjadi tantangan kesehatan masyarakat yang utama di Indonesia, khususnya di wilayah berkembang seperti Kota Palu. Permasalahan ini sering kali diperparah oleh rendahnya literasi gizi orang tua dan terbatasnya akses terhadap pemantauan pertumbuhan secara real-time. Penelitian ini bertujuan untuk mengembangkan dan mengevaluasi SmartNutri, sebuah aplikasi edukasi gizi berbasis Android yang dirancang untuk meningkatkan pengetahuan orang tua dan memfasilitasi pemantauan pertumbuhan secara mandiri. Aplikasi ini mengintegrasikan kalkulator gizi, dasbor pemantauan pertumbuhan, dan rekomendasi menu yang diselaraskan dengan Peraturan Menteri Kesehatan Republik Indonesia Nomor 2 Tahun 2020. Pendekatan mixed-method digunakan dalam penelitian ini, melibatkan 50 orang tua yang dipilih melalui teknik purposive sampling dan 10 kader Posyandu. Pengujian fungsional di 25 skenario menunjukkan bahwa sistem beroperasi dengan benar pada berbagai perangkat, sementara evaluasi Skala Kegunaan Sistem (SUS) menghasilkan skor rata-rata 84,6 ("Sangat Baik"). Selain itu, pengetahuan gizi orang tua meningkat secara signifikan dari 58,4 ± 10,2 menjadi 81,7 ± 8,9 ($p < 0{,}001$) setelah empat minggu penggunaan. SmartNutri berhasil menjembatani kesenjangan antara literasi gizi dan praktik perilaku, menyediakan alat yang dapat diskalakan (scalable) dan ramah pengguna untuk mendukung gizi anak usia dini.

**Keyword**: Literasi Gizi, Stunting, Aplikasi Android, Pemantauan Pertumbuhan, SmartNutri

## 1. Introduction

The period of 0–60 months is widely recognized as the golden period that critically determines a child's long-term health, physical growth, and cognitive development [1]. Despite continuous national efforts, Indonesia still faces major challenges in improving early childhood nutrition. The Indonesia Nutritional Status Survey (SSGI) in 2023 reported that the prevalence of stunting among children under five years old reached 21.5%, which remains significantly higher than the national target of 14.2% by 2029 [2]. This issue is particularly prevalent in developing regions and suburban areas where access to health information remains uneven [3].

The high prevalence of malnutrition suggests that the problem is driven not only by limited food availability but also by low parental nutrition literacy and inadequate growth monitoring at the household level. Parents, particularly mothers, play a crucial role in providing adequate nutrition and maintaining healthy behaviors. However, they often face obstacles such as limited access to reliable nutritional information, time constraints, and a lack of awareness regarding balanced diet principles. In Indonesia, community-based monitoring is typically conducted through the Integrated Healthcare Center (Posyandu). However, the frequency of Posyandu sessions is often limited to once a month, leaving a gap in daily monitoring and continuous education. Without consistent guidance, parents may struggle to implement proper feeding practices.

With the rapid advancement of digital technology, mobile-based interventions have emerged as a promising strategy to bridge this gap [4], [5], [6], [7]. Recent evidence confirms that digital interventions are generally effective in improving nutritional knowledge, attitudes, and healthy behaviors [8], [9]. For instance, mobile applications have been shown to enhance maternal knowledge regarding stunting prevention and improve anthropometric indicators in infants [10], [11]. However, most existing nutrition education applications are not specifically designed to align with the localized needs of Indonesian parents or the specific regulations of the Indonesian Ministry of Health [12]. Furthermore, few studies have integrated comprehensive growth monitoring based on WHO standards with personalized daily menu recommendations in a single platform, while also evaluating the system's usability.

Addressing these limitations requires the development of a comprehensive and contextually relevant digital tool. This study introduces SmartNutri, an Android-based nutrition education application designed to enhance parental nutrition literacy and facilitate regular growth monitoring for children under five years old. Unlike previous applications that operate as static information repositories, SmartNutri integrates a nutrition calculator, daily menu recommendations, and anthropometric-based growth monitoring strictly aligned with the Ministry of Health Regulation No. 2 of 2020 and WHO growth standards [14], [15]. From a technological perspective, the system is built using an Object-Oriented Programming (OOP) approach to ensure modularity, scalability, and ease of maintenance, allowing the application to adapt to evolving medical guidelines without disrupting the user interface [16], [17] [18], [19], [20]. The primary objective of this study is to evaluate the effectiveness of SmartNutri in improving parental nutrition literacy and to assess its usability among parents in Palu City, Indonesia.

## 2. Method

### 2.1. Study Design and Participants

This study was conducted in Palu City, Central Sulawesi. The participants consisted of 50 parents of children aged 0–60 months. Respondents were selected using a purposive sampling technique based on inclusion criteria: (1) residing in the study area, (2) having a child under five years old, and (3) owning an Android smartphone. Additionally, 10 community health workers from the Integrated Healthcare Center (Posyandu) were interviewed to gather system requirements.

### 2.2. System Development Methodology

The application was developed using the Waterfall model [21], which ensures a structured approach through requirements analysis, design, implementation, testing, and maintenance. To ensure system scalability and modularity, the software architecture utilized **Object-Oriented Programming (OOP)** principles. This approach allows for the independent update of medical data modules (e.g., nutrition standards) without disrupting the core application structure [22], [23], [24], [25], [26].

### 2.3. Instruments and Data Collection

Data were collected using two primary instruments:

1. **Nutrition Knowledge Test**: A pre-test and post-test questionnaire consisting of 30 multiple-choice questions to measure changes in parental nutrition literacy.
2. **System Usability Scale (SUS)**: A standardized 10-item questionnaire used to evaluate user satisfaction and the usability of the application [27], [28], [29].

### 2.4. Data Analysis

Functional testing was conducted using black-box testing methods. The effectiveness of the intervention was analyzed using a paired t-test to compare pre-test and post-test nutrition knowledge scores, with a significance level set at $p < 0.05$ [30], [31], [32], [33], [34].

## 3. Results and Discussions

### 3.1. Requirements Analysis

The initial survey revealed that 78% of parents had never received digital nutrition education. Specifically, 82% of respondents desired nutrition intake guidance, and 76% requested features to check their child's nutritional status. Interviews with Posyandu officers highlighted a critical need for a tool that allows parents to monitor growth curves independently between monthly Posyandu visits. A child's nutritional status in the application is assessed based on height and weight measurements [1], [23]. Table 1 presents the demographic characteristics of the respondents.

Table 1. Characteristics of Respondents

| Variable | Category | n | % |
|---|---|---|---|
| Gender | Female | 34 | 68 |
| | Male | 16 | 32 |
| Age (years) | 22–25 | 8 | 16 |
| | 26–30 | 20 | 40 |
| | 31–40 | 22 | 44 |
| Education | Junior High School or Equivalent | 6 | 12 |
| | Senior High School or Equivalent | 29 | 58 |
| | Higher Education | 15 | 30 |
| Employment Status | Housewife | 28 | 56 |
| | Informal Worker | 12 | 24 |
| | Formal Worker | 10 | 20 |

### 3.2. System Design and Architecture

The system architecture Figure 1, consists of four integrated layers: Client, Service, Database, and Data Reference. The Client Layer consists of the Android application, while the Service Layer functions as the backend API responsible for handling business logic, including nutritional requirement calculations and WHO Z-score computations. The application strictly references the Ministry of Health Regulation No. 2 of 2020 and WHO Child Growth Standards.

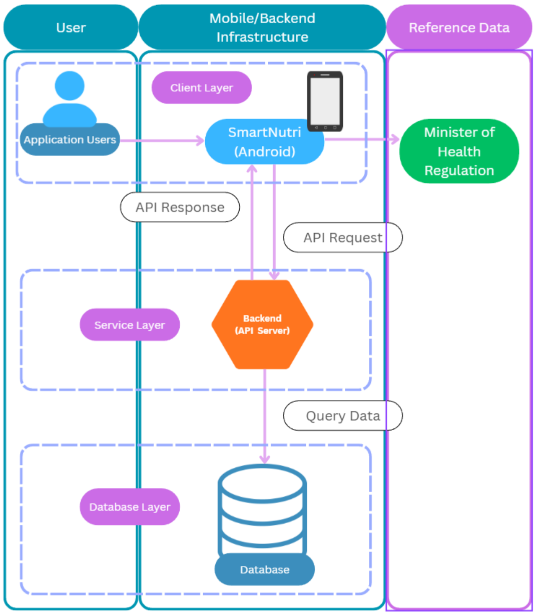


Figure 1. System Architecture Diagram

The design of the *SmartNutri* application was developed based on the needs analysis findings from 50 parents of toddlers and 10 *Posyandu* officers. The survey indicated that 82% of respondents wanted nutrition intake guidance, and 76% required a feature to check their child's nutritional status. In addition, interviews with *Posyandu* officers emphasized the need for a feature to monitor children's height and weight. Child growth can be assessed using the anthropometric standards for nutritional status assessment [23].

The design process included several main components:

1. System Architecture and OOP
   a. The system adopted an Object-Oriented Programming (OOP) approach with core classes such as User, ChildProfile, NutritionCalculator, and GrowthMonitor.
   b. The principles of encapsulation, inheritance, polymorphism, and abstraction were applied to ensure that the nutrition calculator, daily menu, and growth reporting modules could be developed and maintained independently.
2. User Interface (UI/UX) Design
   a. The interface was designed using a mobile-first approach with simple navigation, large buttons, and visually comfortable color schemes.
   b. The main menu includes: Check Nutritional Status, Nutrition Guidance, Growth Monitoring, and Nutrition Education.
3. Nutrition Data Integration
   a. The database for menus and energy calculators was built based on the Indonesian Food Composition Table (TKPI) [27] and the Ministry of Health Regulation No. 2 of 2020 [15].
   b. The nutritional status check feature utilized WHO anthropometric standards to calculate Z-scores based on children's height and weight measurements.

The system architecture diagram of SmartNutri is designed with four main integrated layers. The Client Layer consists of the Android application used by parents to input their child's data, check nutritional status, and display menu recommendations. The Service Layer functions as the backend API responsible for handling business logic, including nutritional requirement calculations, WHO Z-score computations, and menu recommendation generation. The Database Layer stores child profiles, growth history, and menu data collections, which can be updated in real time. As Data References, the application refers to the Ministry of Health Regulation No. 2 of 2020 on Balanced Nutrition Standards and the WHO Child Growth Anthropometry Standards, ensuring that all calculations and menu recommendations comply with both national and international child nutrition and growth guidelines.

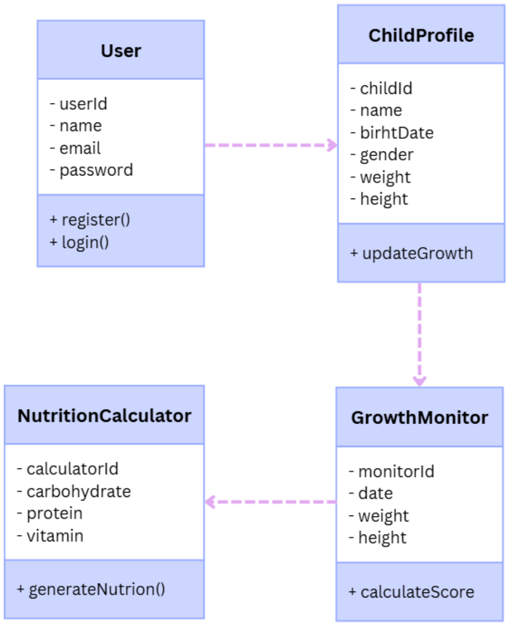


Figure 2. Class Diagram

Figure 2 depicts the Class Diagram designed using OOP principles. The separation of NutritionCalculator and GrowthMonitor classes ensures that changes in calculation formulas do not affect user profile management. The main class diagram of the *SmartNutri* application, developed based on Object-Oriented Programming (OOP) principles, consists of four core classes: User, ChildProfile, GrowthMonitor, and NutritionCalculator. The User class manages parent or health worker accounts, while ChildProfile stores the child's identity and growth measurement history. The GrowthMonitor class calculates and visualizes WHO Z-scores to monitor growth, and the NutritionCalculator determines energy requirements and provides daily menu recommendations. The relationships among classes are designed using encapsulation and composition principles, ensuring that each module authentication, growth recording, nutrition calculation, and menu recommendation can be updated independently without affecting other components.

**3.3. User Interface Implementation**

The user interface (UI) was designed with a mobile-first approach. Figure 3 shows the key interfaces of SmartNutri.

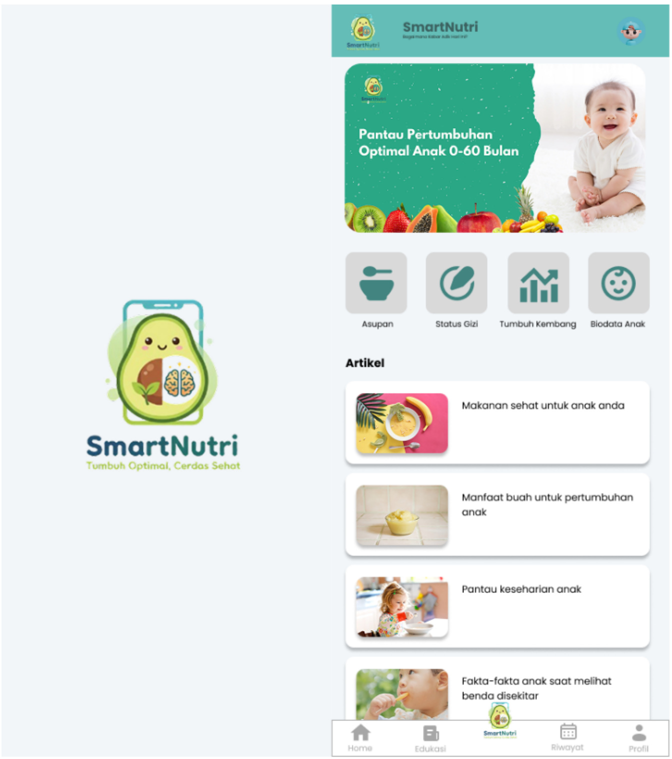


Figure 3. SmartNutri Interface Design

The figure below illustrates the SmartNutri application's user interface (UI) design, developed using a mobile-first approach to ensure user comfort on Android devices. The main display features a Home Screen with simple navigation leading to the core features growth monitoring, nutrition calculator, and menu guidance. Visual elements such as soft-colored icons and large typography were chosen to help parents easily access information. The UI/UX design emphasizes readability, color consistency, and interactive buttons, enabling users to quickly and intuitively input their child's height and weight data and obtain balanced nutrition menu recommendations.

### 3.4. Functional and Usability Testing

Functional testing was conducted across five different Android devices using 25 specific test cases. As shown in Table 2, the system achieved a 100% pass rate for critical modules, including registration, data input, and nutritional status calculation.

Table 2. Functional Testing Results

| Module | Test Cases | Passed | Percentage |
|---|---|---|---|
| Registration & Login | 5 | 5 | 100% |
| Child Data Input | 6 | 6 | 100% |
| Nutritional Status | 6 | 6 | 100% |
| Intake | 5 | 5 | 100% |
| Growth Monitoring | 5 | 5 | 100% |
| Education | 3 | 2 | 80% |

In terms of usability, the application achieved an average System Usability Scale (SUS) score of 84.6, categorized as "Excellent". This indicates that the interface design effectively accommodates users with varying levels of technical proficiency.

### 3.5. Effectiveness on Nutrition Literacy

As illustrated in Figure 4, there was a significant improvement in parental nutrition knowledge. The mean score increased from $58.4 \pm 10.2$ at baseline to $81.7 \pm 8.9$ post-intervention ($p < 0.001$). This finding aligns with previous studies indicating that interactive digital tools can effectively translate complex medical guidelines into actionable parenting knowledge [13, 16]. Unlike passive educational media, SmartNutri's interactive features such as the nutrition calculator encourage active learning.

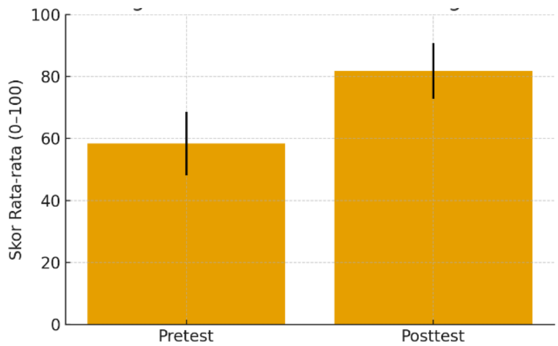


Figure 4. Comparison Chart of Pretest–Posttest Nutrition Knowledge Scores

The maintenance phase was carried out after the *SmartNutri* application was released for field testing. Application improvements were made based on user feedback, including minor adjustments to font sizes. Performance monitoring was conducted via the Laravel server and MySQL database to ensure system stability, with an average API response time of less than 1.5 seconds. Continuous maintenance includes updating nutrition data in accordance with Ministry of Health regulations and WHO standards, enhancing security, and ensuring compatibility with the latest Android versions so that the application remains relevant, effective, and beneficial for parents.

The findings demonstrate that SmartNutri effectively improves parental nutrition literacy, as reflected in the significant increase in mean knowledge scores from 58.4 ± 10.2 to 81.7 ± 8.9 ($p < 0.001$). This notable improvement indicates that digital interventions can translate complex nutrition concepts into practical, culturally contextualized guidance for parents of young children. The high System Usability Scale (SUS) score of 84.6 ("Excellent") highlights strong user acceptance and interface intuitiveness, suggesting that the application's localized design and modular architecture contribute to both usability and engagement. From a technological standpoint, the Object-Oriented Programming (OOP)-based modular structure ensures flexibility and scalability, allowing continuous updates and integration into broader community health systems. Collectively, these findings underline that SmartNutri not only enhances knowledge but also bridges the gap between health literacy and actionable parenting practices key determinants of optimal growth among children aged 0–60 months.

SmartNutri's effectiveness in improving parental nutrition literacy aligns with evidence showing that digital nutrition tools enhance parental knowledge and behavior but have limited impact on child growth outcomes, highlighting the need for longer follow-up and integration of implementation-science approaches to ensure sustained behavior change and measurable anthropometric effects [35], [36].

In the Indonesian context, these results are consistent with randomized controlled trials showing that mobile interventions improve maternal knowledge, self-efficacy, and complementary feeding practices, as well as children's z-scores for stunting, wasting, and underweight following 12–24 weeks of implementation [37]. Comparable approaches have been used in mobile health promotion tools developed for obesity prevention among adolescents, emphasizing participatory design and iterative usability testing as essential elements of effective digital health innovation [38].

Implementation fidelity the extent to which an intervention is delivered as intended has also been identified as a critical determinant of digital intervention success [39]. SmartNutri's structured deployment and adherence to evidence-based nutrition content reflect this principle. From a usability perspective, its "Excellent" SUS score is consistent with high engagement and satisfaction levels reported in other dietary monitoring applications for Indonesian adolescents [40]. Both findings underscore the importance of clear interface design, interactivity, and cultural adaptation in sustaining user engagement.

Likewise, web-based interventions promoting balanced diet and healthy weight among Indonesian pregnant women have proven effective in improving nutritional knowledge and dietary behavior [41]. Together, these findings demonstrate that digital nutrition interventions tailored to local contexts can substantially enhance health literacy and preventive nutrition behaviors [13].

Despite these promising results, this study has several limitations. The six-week intervention period was relatively short to observe sustained behavioral or anthropometric changes, such as improvements in height-for-age [37]. Reliance on self-reported measures may have introduced response bias, and the limited sample size from a single region constrains generalizability. Furthermore, the SmartNutri prototype currently lacks adaptive features such as AI-driven menu personalization or predictive analytics, and user engagement was measured only immediately after intervention without longitudinal tracking.

From a technological standpoint, the use of an OOP-based modular architecture and the Waterfall model demonstrates the feasibility of developing scalable and user-friendly digital health applications. Future iterations could integrate machine learning for real-time growth prediction and dietary recommendations. From a public health perspective, SmartNutri contributes to enhancing parental nutrition literacy an essential determinant in preventing undernutrition and stunting.

At the policy level, integration of SmartNutri into community health infrastructures such as *Posyandu* and *Puskesmas* could strengthen real-time monitoring and evidence-based decision-making. The application's alignment with Indonesia's National Strategy for Stunting Reduction (2021–2030) and the Digital Health Transformation Roadmap (2024–2030) underscores its scalability and policy relevance. Overall, SmartNutri exemplifies how digital innovation can bridge knowledge–practice gaps, strengthen family-level preventive health behaviors, and support national efforts to reduce stunting and improve child health equity.

## 4. Conclusions

SmartNutri was successfully developed using OOP principles to provide a scalable and robust nutrition education tool. The application demonstrated high usability (SUS score of 84.6) and proved effective in significantly improving parental nutrition literacy ($p < 0.001$) in Palu City. By enabling independent growth monitoring and providing localized menu recommendations, SmartNutri supports national efforts to reduce stunting among children under five years old. Future development should focus on integrating AI-based personalized recommendations and expanding the scope to include real-time data synchronization with local Public Health Centers (Puskesmas).

## 5. Acknowledgement

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## 6. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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