

Digital Health Interventions to Improve Parental Literacy and Nutritional Status of Preschool-Aged Children: A Systematic Review

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ABSTRACT

Background: Nutrition of preschool children, especially toddlers, greatly determines the quality of life of children in the future. In line with the rapid development of information technology in the digital era, many health promotion media have been developed to improve the digital literacy of parents. Assessment of children's nutritional status by utilizing technology is considered more accurate and easily accessible to parents. This study aims to conduct a systematic review related to digital health interventions as an effort to improve parental literacy and nutritional status of children under five.

Subjects and Method: This study is a systematic review using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach. Articles were obtained from Scopus, PubMed, ScienceDirect, Web of Science, and Google Scholar databases for the period 2020-2025. Inclusion criteria include English-language studies, quantitative, qualitative, and mixed-methods research, full text, evaluating digital tools, AI-based models, or behavioral-based approaches to improve the nutritional status and eating behavior of toddlers. The assessment of the quality of the study uses Critical Appraisal Skills Programs (CASP) for quantitative and qualitative research.

Results: 7 articles were found consisting of 2 articles from China and Sweden, 1 article each from Indonesia, Thailand, Nigeria. The use of digital technology has developed in various countries with a focus on improving parents' digital literacy, especially related to children's health, including anthropometric measurements, assessment of children's nutritional status, and dietary recommendations based on the results of nutritional status analysis.

Conclusion: Digital health intervention innovations are considered effective in improving parental literacy and nutritional status of children under five

Keywords: toddler nutrition, nutrition monitoring, digital health, mHealth, artificial intelligence, diet, parental literacy.

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BACKGROUND

Good nutrition in toddlers is very important to pay attention to because in this period as a critical period, the right nutritional intervention has a long-term impact on the health and potential of children. This period is a golden age with physical growth and cognitive development occurring very rapidly so that the fulfillment of nutritional needs is very crucial. Malnutrition, whether in the form of malnutrition or malnutrition, micronutrient deficiencies, or more nutrients, can result in growth disorders, decreased cognitive abilities, and increased risk of chronic diseases (UNICEF, 2024). There are 45% of deaths of children under five in the world due to malnutrition, with the highest prevalence occurring in low- and middle-income countries (WHO, 2024). Riskesdas data shows that the prevalence of stunting among toddlers reaches 30.8% as well as a serious challenge in efforts to improve child nutrition (Ministry of Health of the Republic of Indonesia, 2018).

Assessing the nutritional status of toddlers requires special time and skills, such as measuring weight, height, upper arm circumference, and head circumference (Ali and Faida, 2022). Several obstacles when interpreting data such as manual data collection errors, low parental involvement and lack of real-time feedback for nutritional improvement are the causes of the less effective monitoring process of nutritional status of toddlers (Areemit et al., 2023). This is exacerbated by an uneven health information system that reaches rural areas and limited human resources in primary health facilities such as Posyandu.

Along with the development of technology and advances in the field of artificial intelligence, online applications that detect nutritional status in toddlers are a solution. The data input allows for a quick and accurate assessment of the nutritional status of

toddlers (Ritongga, 2024). Several methods of monitoring the nutritional status of toddlers to increase parental involvement in the formulation of nutrition accurately and efficiently through the development of digital technology, including through mobile health applications (mHealth), eHealth platforms, and artificial intelligence (AI)-based systems. Research by Santoso created an AI-based nutritional status prediction model using attention-based deep learning aimed at improving accuracy and assisting interpretation, which can detect the risk of malnutrition at an early stage through multidimensional data, including food intake, anthropometry and environmental social factors (Santoso et al., 2025). The use of this technology is expected to increase parents' digital literacy in children's health information. The more information parents get, the more likely it is to implement the practice of implementing a healthy lifestyle related to a healthy diet (Uce, 2018).

Research by Zhou on digital interventions in the form of eHealth through the WeChat platform in the form of a module in China for parents and caregivers of toddlers showed positive results on children's diet, physical activity, and increased parental awareness of the importance of children's health. This module makes it easier for parents to access information about children's health information and record children's growth and development. This module has been implemented in China and has been proven to increase health literacy (Zhou, 2024). Another study focusing on healthy food selection applications states that through the MINISTOP 2.0 application that has just been developed in Sweden, it is considered an effective application as a means of promoting children's health and effectively increasing the knowledge of parents or caregivers of toddlers (Alexandrou et al., 2023).

Another study in Nigeria shows that digital health apps are relevant for increasing the knowledge of mothers with children under five compared to conventional methods through counseling. Researchers developed a Baby Thrive application that contains information about feeding practices in toddlers that can be easily accessed by mothers under five can improve healthy feeding practices in children under five (Sosanya et al, 2024).

The various technologies developed not only focus on delivering health information to parents but also in the scope of recording and monitoring children's growth and development. A KhunLook app that has been developed in Pakistan has gained quite high user satisfaction. This mobile-based application integrates a child nutrition status monitoring system and information related to children's health that can be easily accessed by parents or caregivers of toddlers. Research related to digital technology innovations in health promotion and improvement of children's nutritional status has been extensively researched, but local values and integrated communities still need to be developed in order to produce good behavior change. This systematic review aims to synthesize the latest evidence on models and tools for monitoring the nutritional status of toddlers and their role in optimizing diet. It is hoped that the findings will contribute to the development of an evidence-based, integrated digital monitoring framework, which supports early detection, encourages healthy eating practices, and ensures sustainable nutritional improvement in childhood.

SUBJECTS AND METHOD

1. Study Design

This study is a systematic review using the PRISMA (Preferred Reporting Items for Systematic Review and Meta Analysis)

approach. The process carried out by the author consists of 5 stages: 1). Conducting the formulation of research questions; 2). Conducting an article search in the database to find articles relevant to the topic; 3). Selecting articles using the inclusion and exclusion criteria that have been set; 4). Conducting relevant data extraction and analysis; 5). Synthesize findings into tables and draw conclusions appropriately. All of these procedures are carried out in accordance with the PRISMA protocol to ensure methodology. The research questions were developed in PICO (Population, Intervention, Comparison, Outcome).

2. Population and Sample

A literature search was conducted using five major academic databases: Scopus, PubMed, ScienceDirect, Web of Science, and Google Scholar. The search strategy was developed by combining relevant keywords using Boolean operators (AND, OR) and adapted to the indexing and structure of each database. Keywords included terms such as ("digital health" OR "mobile applications" OR "smartphone app") AND ("health literacy" OR "parental health literacy" OR "health education") AND ("preschool children" OR "child nutrition"). The study population comprised parents or caregivers of children aged 1–5 years. The intervention focused on digital health technologies, compared to no intervention or non-digital interventions, with outcomes assessing improvements in parental knowledge and behavior related to providing healthy food for children. Inclusion criteria were primary research articles published in English between 2020 and 2025, available in full text, and focusing on the use of digital technology to improve parental literacy and the nutritional status of toddlers.

3. Study Instruments

The study selection and reporting process follows the PRISMA flowchart as a tool to

synthesize articles. The articles that have been found are then systematically extracted using standard forms developed in Microsoft Excel including information such as the author's name, year of publication, study design, sample population, type of intervention, results, and key findings.

4. Data Analysis

Data analysis and synthesis were conducted using a narrative approach to identify key themes across studies. Findings were grouped based on intervention type (mobile apps, eHealth, AI), study design, and outcomes (parental knowledge, behavior, and nutritional status). A gap analysis was also performed, highlighting limitations such as short study duration, limited long-term evaluation, and lack of family-centered approaches.

RESULTS

1. Prisma Flow Diagram

This systematic review includes studies related to digital health interventions to improve parental literacy and the nutritional status of preschool-aged children. A total of 656 articles were identified from the databases, with the distribution as follows: 348 articles from Google Scholar; 105 articles from Scopus; 28 articles from PubMed; 21 from ScienceDirect; and 154 from Web of Science. Before the screening process began, 239 records were excluded due to duplication (n = 86), non-English or non-primary research (n = 78), and limited full-text access (n = 84). Thus, 417 articles proceeded to the screening stage based on titles and abstracts.

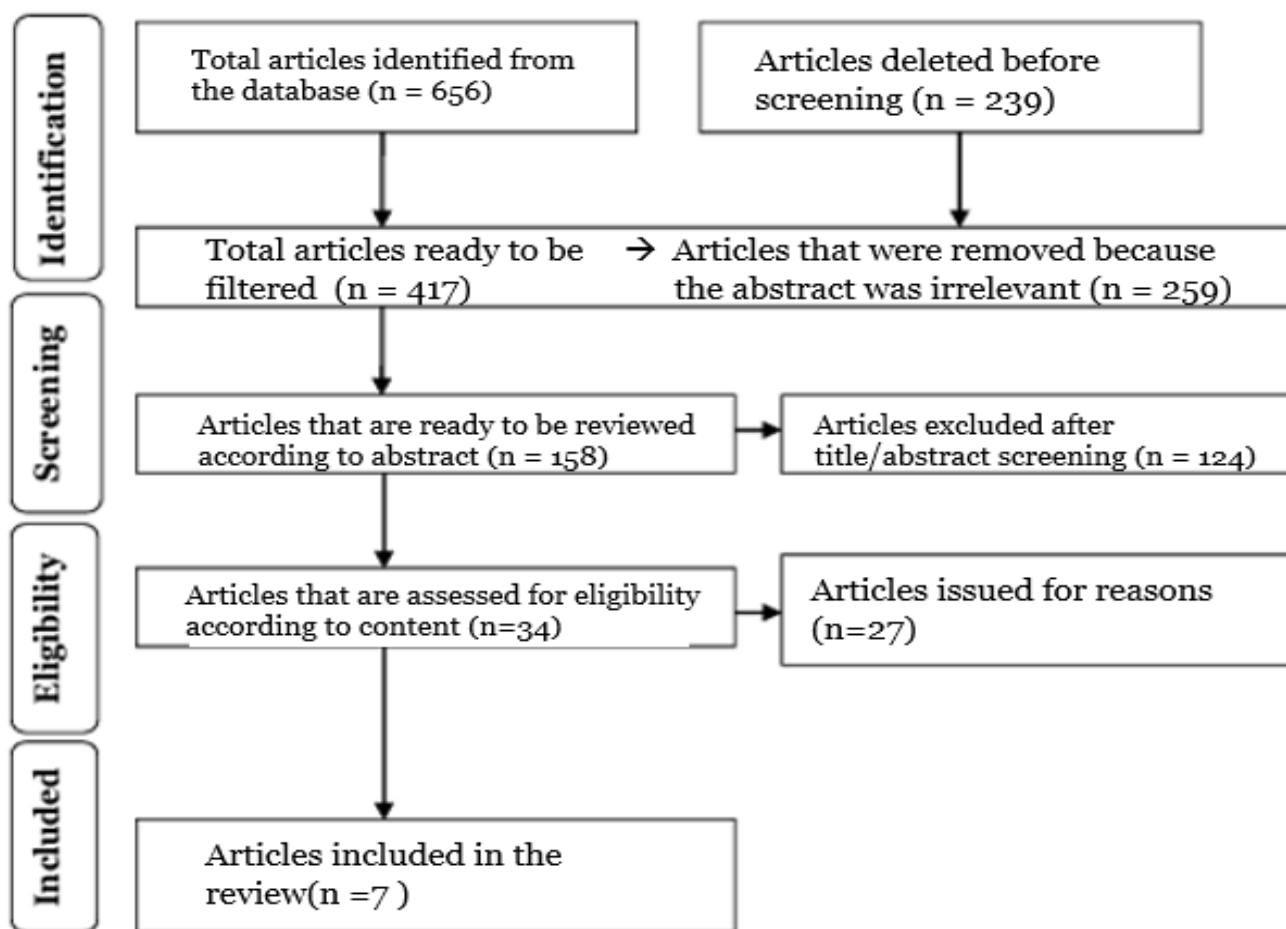


Figure 1. Prisma Flow Diagram

At this stage, 259 articles were excluded because they were irrelevant to toddler nutrition or diet optimization, focused on adult or school-age populations, or did not address digital-based nutrition monitoring and assessment. This left 158 articles eligible for abstract review. After further screening, 124 articles were excluded for similar reasons. As a result, 34 full-text articles were assessed for eligibility, with 27 articles excluded for not meeting the inclusion criteria.

Finally, 7 studies met all the inclusion criteria and were included in this systematic

review. The study selection process is summarized in the PRISMA flowchart (Figure 1), providing a clear overview of the identification, screening, eligibility, and inclusion stages.

2. Maps of Study included

Figure 2 shows a map of the distribution of study articles on digital health interventions in an effort to improve parental literacy and nutritional status of preschool-age children, it can be seen that the majority of research articles come from China as many as 2 articles.

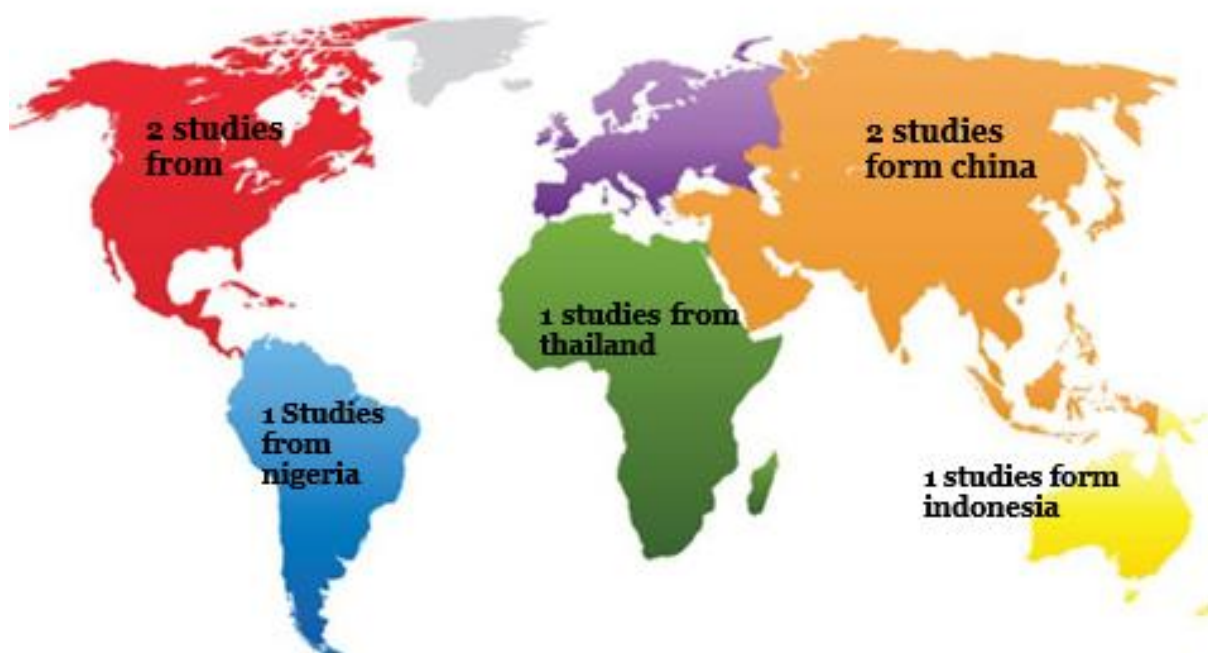


Figure 2. Map of the distribution of articles included

3. Description study

This table presents the Population–Concept–Context (PCC) framework used to describe the characteristics of the articles included in this study. The PCC framework is applied to systematically map the evidence by identifying the study popu-

lation, the main concepts investigated, and the context in which the research was conducted. Through this approach, the table provides a clear and structured overview of the selected studies, facilitating the understanding of how each article contributes to the overall analysis of this research.

Table 1. Characteristics of Selected Studies

Author (Year)	Country	Study Design	Population (P)	Concept (C)	Context (C)	Key Notes
Zhou et al. (2024)	China	Randomized Controlled Trial (RCT)	Parents and preschool children	eHealth, parental literacy	Community & digital platform (WeChat)	eHealth via social media improved diet, physical activity, and parental awareness; low-cost and scalable intervention
Alexandrou & Henriksson (2023)	Sweden	Randomized Controlled Trial (RCT)	Parents and preschool children	Mobile app (MINISTO P 2.0), health promotion	Primary health care	Increased fruit & vegetable intake, reduced unhealthy food; improved parental self-efficacy, but no significant BMI difference
Sosanya & Samuel (2024)	Nigeria	Qualitative (FGD)	Mothers of toddlers	Mobile gaming app, health education	Rural community	BabyThrive app improved maternal knowledge significantly; high usability but limited evidence on behavior change
Areemit et al. (2023)	Thailand	Randomized Controlled Trial (RCT)	Parents of children under five	Mobile app (KhunLook), health literacy	Clinical/health care setting	Improved parental literacy and accuracy in child health assessment; more practical than conventional methods
Frattofillo (2025)	Sweden	Cross-sectional	Parents & caregivers of under-five children	Digital health interventions, obesity management	Community & digital health system	Digital tools improve literacy, behavior, and BMI; challenges include access inequality and data privacy
Susanto (2025)	Indonesia	Cross-sectional	Parents & caregivers of toddlers	AI, IoT, nutritional prediction	Digital health system	AI-based models improve accuracy of nutritional status assessment; real-time monitoring enhances decision-making
Zhou (2024)	China	Randomized Controlled Trial (RCT)	Parents and preschool children	eHealth intervention, health education	Community & digital platform	Significant increase in maternal knowledge using interactive eHealth modules vs. conventional methods

Digital health interventions consistently demonstrated effectiveness in improving parental health literacy and promoting healthy feeding behaviors among caregivers of preschool-aged children. Zhou et al.

(2024) conducted a randomized controlled trial in China using eHealth interventions delivered through social media platforms, showing improvements in children’s diet, physical activity, and parental awareness.

The intervention was considered feasible, low-cost, and capable of reaching a wider population, highlighting the scalability of digital platforms. Similarly, Alexandrou and Henriksson (2023) reported that the MINISTOP 2.0 mobile application significantly improved children's dietary patterns, particularly increasing fruit and vegetable intake while reducing unhealthy food consumption, although no significant changes were found in BMI outcomes.

Mobile-based and interactive applications also showed strong potential in enhancing maternal knowledge. Sosanya and Samuel (2024) developed the Baby-Thrive mobile gaming application in Nigeria, which significantly improved maternal knowledge compared to conventional education methods ($p < 0.001$). Likewise, Areemit et al. (2023) demonstrated that the KhunLook mobile application in Thailand significantly increased parental health literacy and improved the accuracy of child health assessments, indicating that digital tools can support both knowledge and practical skills in monitoring child growth and development.

Advanced digital technologies such as artificial intelligence (AI) and integrated systems further contributed to improving nutritional monitoring. Susanto (2025) showed that AI-based models combined with IoT systems provided accurate and real-time predictions of children's nutritional status, enhancing decision-making and transparency in health monitoring. In addition, Frattolillo (2025) highlighted that broader digital health interventions, including mobile applications, educational games, and wearable devices, were effective in improving nutritional literacy, promoting healthy behaviors, and addressing childhood obesity, although challenges such as unequal access and data privacy remain.

Across studies, consistent findings indicate that digital health interventions improve parental knowledge, self-efficacy, and behavior related to child nutrition. However, several limitations were identified, including short intervention durations, limited evaluation of long-term outcomes, and the need for more inclusive, family-centered approaches beyond focusing solely on mothers. Overall, the evidence suggests that integrating mobile health applications, eHealth platforms, and AI-based systems can significantly enhance parental literacy and support better nutritional outcomes in preschool-aged children, particularly when combined with accessible, user-friendly, and scalable digital solutions.

DISCUSSION

This systematic review integrates research results from 7 articles that explore various digital health applications as an effort to improve the nutritional status of children under five through parental health literacy. These findings show that the role of digital technology, artificial intelligence (AI) and health applications has grown rapidly in a variety of country contexts, including high-income countries such as Sweden and Australia to low- and middle-income countries such as Nigeria, Ethiopia, and Thailand. The findings of the consistently reviewed studies show that digital technology innovations have the potential to improve nutrition knowledge, and healthy food selection practices among parents or caregivers of toddlers.

The seven articles in this study show that health technology interventions have high effectiveness in increasing parental health literacy in the practice of healthy food selection and monitoring the nutritional status of toddlers. Mobile applications using social media for health promotion and artificial intelligence models are considered

quite practical to assess the nutritional status of toddlers which contributes significantly to improving digital literacy, increasing awareness of the importance of maintaining children's health, as well as more positive health-related behavioral changes, especially healthy feeding practices.

There are 2 research RCT articles from China in the same year, namely 2023 by Zhou et al and Sweden Alexandrou et al, it can be concluded that there is a consistency in the results of interactive applications or eHealth that can effectively improve the knowledge of mothers with children under five. This technology-based approach also has the advantages of being more accessible, flexible, easy to use, and accessible whenever needed easily. Parents can access children's health information anywhere and anytime (Zhou et al, 2023).

Other analysis results were obtained from several articles that healthy eating practices after being intervened using the ministop 2.0 application significantly increased the consumption pattern of healthy foods such as fruits and vegetables. Despite the change in practice, it is still constrained by a short research period (Sosanya et al, 2024). The conclusion obtained is that the application still needs development to meet user friendliness in order to improve the quality of the information provided. Some of the applications that are still being developed are the KhuunLook application from Thailand which increases the effectiveness and accuracy of assessing the growth and nutritional status of children (Aremit, 2023), the Baby Thrive application in Nigeria which focuses on improving mothers' knowledge of child-feeding practices, and eHealth in China which focuses on improving the healthy living behavior of children under five.

Increasing parental health literacy is very important because it has a direct effect

on healthy feeding practices for children. This is in accordance with the concept of Health Empowerment, that information and digital technology support increase parents' confidence in children's health practices, so that they are expected to be able to make appropriate health decisions (Zhou, 2024). The results of the study are in accordance with the Health Belief Model (HBM) theory regarding increasing information and knowledge can increase preventive measures against the risk of health problems that arise. Parents' belief in children's susceptibility to diseases raises awareness of the importance of maintaining children's health through providing balanced nutritional intake. Digital technology can provide a variety of health information and messages in the form of interactive education that acts as cues to action to improve healthy behavior for parents. Meanwhile, Social Learning theory states that observation, practice and social interaction can increase behavior change positively (Abraham, C., 2015).

The integration of IoT and Ai based provides a new perspective through monitoring children's nutrition using AI-based concepts. Through accurate prediction of nutritional status based on the WHO Z score and nutritional dietary recommendations, it is hoped that it can reduce the risk of malnutrition. The implementation of IoT in child nutrition monitoring has the advantages, namely it can be seen in real time, can accurately predict children's nutritional status and is automatically detected if children tend to be malnourished. Although the information available in the application is complete, support and awareness from parents are needed to improve the quality of child health monitoring (Susanto, 2025).

The limitations of this research are especially related to the duration of the research which is only 3-6 months on average or ranges from short duration so that

long-term conclusions cannot be drawn. Another limitation is that some applications require an internet connection or must be run online so that they are less applicable in areas with limited internet access.

Most of the research articles are still focused on knowledge and behavior, but no one has assessed the accuracy of the application in terms of the validity of the information in the application and the accuracy of the assessment of children's nutritional status. All research articles focus on mothers not families, so for future research, there is a need for a family-centered care approach that involves all family members.

This systematic review highlights the overall potential of digital technologies that have a positive impact on improving parental health literacy and nutritional status assessment. Health digital technology has a strategic role in providing health information and preventing child nutrition problems. Although there are still limitations related to network access constraints, data privacy, and application sustainability, future research will be better if it focuses on developing an integrated and culturally adaptive monitoring model. This is realized through the combination of real-time digital tracking, predictive analytics, and community-based education. This evidence-based framework will strengthen early detection of dietary management in toddlers and support policymakers and health professionals to implement sustainable technology-based strategies to address underage malnutrition and promote healthy eating practices.

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CONFLICT OF INTEREST

There are no conflicts of interest.

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