EVALUATING THE EFFECTIVENESS OF MOBILE APPLICATIONS FOR NUTRITION EDUCATION AND EARLY CHILDHOOD DEVELOPMENT MONITORING IN LITERATUR REVIEW.

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Abstract

Early childhood is a critical period for nutrition and developmental health. However, children in low- and middle-income countries remain vulnerable to undernutrition and developmental delays. Mobile health (mHealth) technologies have emerged as scalable tools to improve caregiver knowledge and child monitoring, but evidence on their effectiveness remains fragmented. This Literatur review aimed to map and evaluate the characteristics, functionalities, and reported outcomes of mobile applications designed for nutrition education and early childhood development monitoring for caregivers of children aged 0–5 yearsFollowing Joanna Briggs Institute methodology and PRISMA-ScR guidelines, five databases were searched for English-language studies published from January 2019 to May 2025. Included studies featured mobile app-based interventions focused on nutrition and/or developmental monitoring, with outcomes related to caregiver knowledge, behavior change, or child health. Narrative synthesis was used to group findings thematically. Of 1,240 records, 10 studies met the criteria. Interventions clustered into three categories: (1) nutrition apps (e.g., MyKid'sNutrition), (2) behavioral/developmental apps (e.g., BabyThrive), and (3) integrated tools addressing multiple domains (e.g., dietary self-monitoring apps). Most used smartphones, multimedia education, and behavior change features like goal-setting. While studies showed positive trends in knowledge and child outcomes, methodological limitations and varied outcome measures limited comparability. Mobile apps offer promising support for early childhood nutrition and development. Future research should focus on standardized outcomes, longer-term impacts, and culturally appropriate implementation across diverse settings.

Keywords . Early childhood, Development Mobile applications, Nutrition education

1. INTRODUCTION

The early years of a child's life are foundational for physical, cognitive, and behavioral development. During this stage, children are especially vulnerable to nutritional deficiencies and growth-related challenges. Malnutrition—whether due to insufficient intake, imbalanced diets, or lack of essential nutrients—continues to be a major factor in child illness and death, particularly in low- and middle-income countries (UNISEF, 2023). At the same time, many children worldwide experience developmental setbacks that negatively affect their future learning, health, and socioeconomic potential (Black et al., 2017).These dual challenges are especially acute in under-resourced communities, where access to reliable health education, proper nutrition, and consistent developmental monitoring is limited (WHO., 2021). (WHO, 20 Although global initiatives such as the Sustainable Development Goals and WHO's Nurturing Care Framework highlight the importance of early childhood well-being, the widespread implementation of sustainable, high-impact strategies remains a major hurdle.

Advancements in digital health, particularly mobile-based solutions, are increasingly being adopted to deliver health information and services. Mobile health (mHealth) platforms provide caregivers with tools for learning, monitoring, and behavior tracking, potentially enhancing their ability to support their children's development (Lee et al., 2022). The rise in smartphone use, even in lower-income settings, creates opportunities to reduce information gaps and strengthen early childhood outcomes (Free et al., 2022). However, findings from individual studies vary widely, and little consensus exists on the effectiveness or design of such digital tools for early childhood needs.

The lack of synthesized evidence makes it difficult for stakeholders to identify replicable, evidence-informed interventions. Existing reviews often generalize mHealth impacts without specifically addressing their role in nutrition and child development. To address this, a broad literature mapping is necessary to understand how mobile applications are structured, what they aim to achieve, and how effective they are.

Given the diversity in approaches and study quality, a scoping review is the most suitable method to explore this evolving field. This approach, aligned with Joanna Briggs Institute methodology and PRISMA-ScR standards, is useful for identifying research gaps, clarifying conceptual boundaries, and guiding future systematic investigations (Peters et al., 2020; Tricco et al.,2018)).The current review aims to systematically examine existing mobile applications designed to support nutrition education and developmental monitoring for caregivers of children under five years old.

2. METHODOLOGY

Study Design and Protocol Registration

This study employed a systematic review design to synthesize existing evidence on the effectiveness of mobile applications in delivering nutrition education and monitoring early childhood development. The review process adhered strictly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological rigor and transparency (Page et al., 2021). Although the review followed a structured and pre-defined protocol, it was not prospectively registered in an international registry such as PROSPERO.

Eligibility Criteria

Eligibility criteria were established using the PICOS (Population, Intervention, Comparison, Outcomes, Study Design) framework. The population of interest included parents or caregivers of children aged 0–5 years. Interventions were defined as mobile application-based tools aimed at providing nutrition education and/or monitoring developmental milestones in early childhood. Studies were included irrespective of whether a control or comparison group was present. Outcomes of interest encompassed improvements in parental knowledge, behavioral changes related to nutrition, and indicators of child developmental progress. Eligible study designs included randomized controlled trials, quasi-experimental studies, cohort studies, and relevant observational studies. Only peer-reviewed journal articles published between January 2019 and May 2025 were considered, to ensure currency and relevance with rapidly evolving mobile health technologies. Articles published in English were included, while those in other languages were excluded due to resource limitations. Conference abstracts, editorials, opinion pieces, and non-peer-reviewed literature were excluded to maintain methodological quality.

Information Sources and Search Strategy

A comprehensive literature search was conducted across five electronic databases: PubMed, Scopus. The final search was executed on May 30, 2025. The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to "mobile applications," "nutrition education," "early childhood development," and "monitoring." Boolean operators (AND, OR) were used to refine the results. To minimize publication bias and enhance inclusivity, reference lists of all eligible studies and

relevant reviews were manually screened for additional articles. Grey literature was not included in this review, as the focus was confined to peer-reviewed academic sources. The last search was conducted on Juni, 2025. Further details of the search methods from each database are available in Supplementary File 1.

Study Selection Process

The study selection process was conducted in two sequential stages. Initially, titles and abstracts were independently screened by two reviewers to identify studies that met the inclusion criteria. Subsequently, full-text articles were assessed to confirm eligibility. Any discrepancies between the reviewers were resolved through discussion and consensus; a third reviewer was consulted when necessary. The screening and selection process was facilitated using Rayyan, a web-based tool designed for systematic review management, which improved the accuracy and efficiency of the process (Quzzani et al., 2016).

Data Extraction and Management

Data from the included studies were extracted using a standardized and piloted data extraction form to ensure uniformity. The extracted data included authorship, year of publication, study setting, population characteristics, intervention details, outcome measures, results, and conclusions. Two reviewers independently extracted the data, and any disagreements were reconciled through discussion or by consulting a third reviewer to ensure reliability and consistency. The completed data extraction forms were cross-checked for completeness and accuracy before synthesis.

Quality Assessment / Risk of Bias

To appraise the methodological quality of the included studies, the Joanna Briggs Institute (JBI) Critical Appraisal Tools were employed, tailored to the specific design of each study type. Each article was evaluated independently by two reviewers, focusing on criteria such as selection bias, measurement validity, confounding factors, and appropriateness of statistical analyses. Studies were not excluded based on quality scores alone; however, the risk of bias assessments informed the interpretation of findings and the robustness of the overall evidence base.

Data Synthesis and Analysis

Due to the heterogeneity of study designs, interventions, and outcome measures, a narrative synthesis was conducted. This approach allowed for thematic grouping and qualitative comparison of study results, highlighting patterns in the effectiveness of mobile applications across various contexts. Where feasible, studies were grouped based on the type of intervention (nutrition education, developmental monitoring, or combined approaches) and target outcomes. A meta-analysis was not performed given the variability in outcome reporting and measurement tools across the included studies.

Ethical Considerations

As this study involved the synthesis of previously published research, no new data were collected, and no direct involvement with human subjects occurred. Consequently, ethical approval was not required. All data sources were publicly accessible and properly cited to respect intellectual property and academic integrity.

3. RESULTS

Searching results

A total of 1,240 records were identified through database searching. No additional records were retrieved from other registers. After the removal of 240 duplicates, 1,000 records remained and were subjected to title and abstract screening. Of these, 900 records were excluded for not

meeting the inclusion criteria. The full texts of 100 articles were sought, of which 10 could not be retrieved. The remaining 90 full-text articles were assessed for eligibility. A total of 80 articles were excluded for the following reasons: wrong population (n = 30), wrong intervention (n = 30), wrong context (n = 20), and wrong study design (n = 10). Ultimately, 10 studies were included in the final systematic review. (Figure 1).

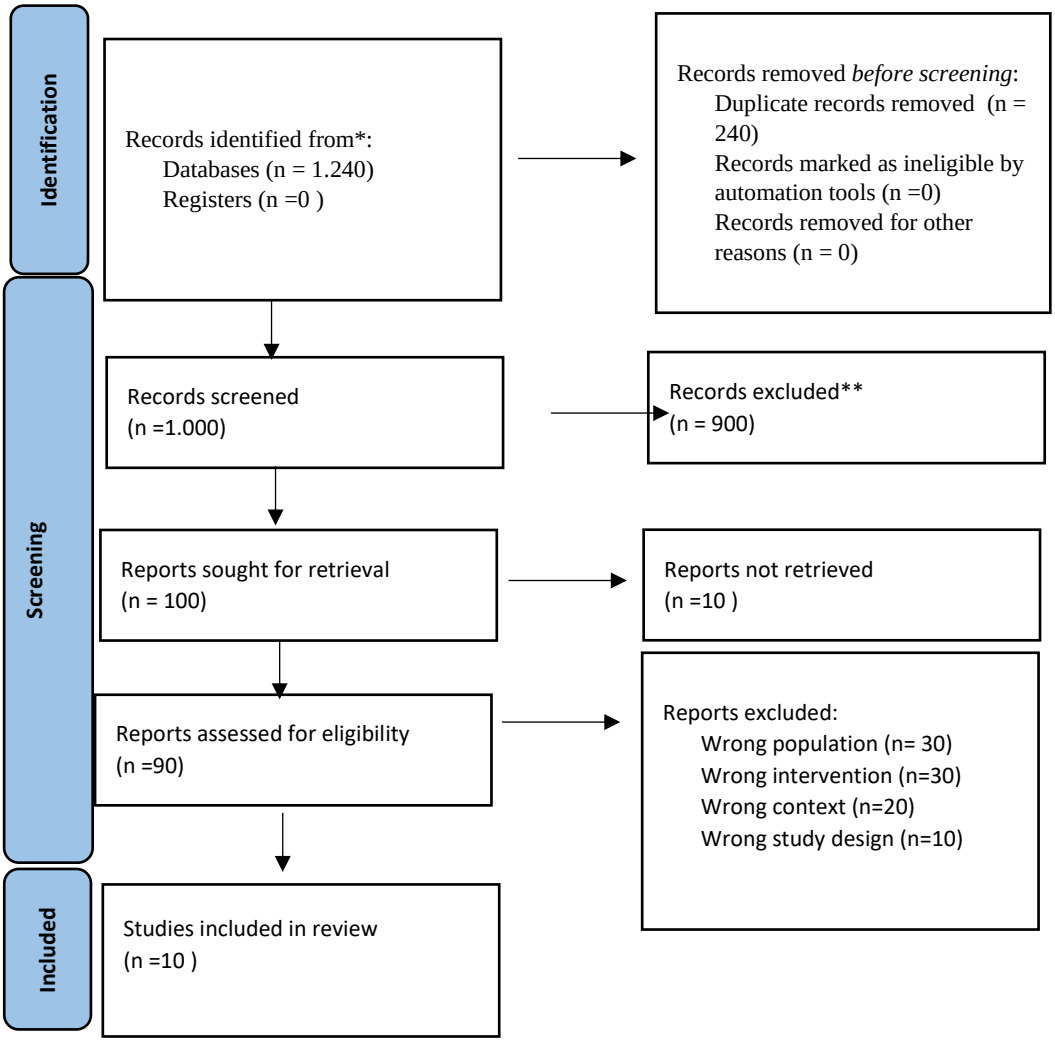

Figure 1. PRISMA flow diagram

1.1 Characteristic of included studies

Geographic and Demographic Distribution

The studies were conducted across various regions, with notable representation from Asia (Iran: Hojati et al., 2023; Mousavi Ezmareh et al., 2024; Malaysia: Er et al., 2023) (, Africa (Nigeria: Sosanya et al., 2024), Europe (Italy: Gabrielli et al., 2017), and the United States (Thompson et al., 2025; Nezami et al., 2022), as well as global or multi-country analyses (Perego et al., 2020; Ulfa et al., 2022; Kustiawan et al., 2022). The targeted populations predominantly included mothers of children aged 0–5 years or caregivers of children experiencing undernutrition or overweight, with one study focusing on teenage mothers in low-resource settings (Sosanya et al., 2024), and another involving parents of children aged 2–12 (Nezami et al., 2022).

Study Designs and Methodological Trends

The designs ranged from randomized controlled trials and quasi-experimental studies (Hojati et al., 2023; Mousavi Ezmareh et al., 2024; Nezami et al., 2022), to formative or validation studies using mixed or user-centered approaches (Gabrielli et al., 2017; Sosanya et al., 2024; Thompson et al., 2025). Two systematic reviews (Perego et al., 2020; Kustiawan et al., 2022) and one bibliometric analysis (Ulfa et al., 2022) offered a broader synthesis of current trends in digital nutrition applications. Several protocols reflected ongoing or preparatory phases of research (Perego et al., 2020; Hojati et al., 2023; Er et al., 2023), while others had completed interventions with measurable outcomes.

Intervention Features and Functionalities

All interventions utilized mobile platforms, often integrating multimedia education, behavioral monitoring, goal-setting, and feedback mechanisms. Apps commonly included features for dietary tracking, nutritional education, growth monitoring, or coaching (Gabrielli et al., 2017; Hojati et al., 2023; Nezami et al., 2022). Some studies adopted innovative formats, such as the use of gamification and dual-language capability to support feeding practices among teenage mothers (Sosanya et al., 2024). or the conceptual mapping of parental preferences to guide app design (Thompson et al., 2025). Several apps targeted both maternal and child behaviors, such as BabyThrive and MyKid'sNutrition, whereas broader surveillance tools were emphasized in reviews by Perego et al. (2020) and Kustiawan et al. (2022).

Outcome Domains and Effectiveness

A range of outcome domains were reported, including parental nutritional knowledge, dietary behavior change, child anthropometric improvements, and self-efficacy. Interventions such as those by Mousavi Ezmareh et al. (2024) and Nezami et al. (2022) demonstrated statistically significant improvements in child growth indicators and parent–child dietary concordance, respectively. Similarly, BabyThrive was associated with enhanced maternal IYCF knowledge and user satisfaction (Sosanya et al., 2024). Even among protocol studies, outcome frameworks consistently prioritized child nutritional status, behavior change, and maternal engagement (Hojati et al., 2023; Er et al., 2023).

Implementation and Engagement

Implementation strategies varied widely. Most interventions were delivered via smartphones and integrated into routine health care or educational frameworks. Some studies used pilot testing and iterative feedback (Gabrielli et al., 2017), others employed crossover trials (Sosanya et al., 2024), and several utilized longitudinal follow-up for monitoring progress (Er et al., 2023). Engagement levels were generally reported as high, inferred from user compliance, usability ratings, and outcome adherence, though some studies (e.g., protocols) did not yet provide usage metrics.

Technological Scope and Trends

All studies leveraged mobile technology for behavior change, with common use of tracking tools, reminders, and real-time feedback. The use of adaptive educational content and bilingual interfaces (e.g., Hausa and English in BabyThrive) reflected efforts to enhance accessibility and contextual relevance (Sosanya et al., 2024). Bibliometric and systematic reviews pointed to an increasing global trend in the use of mobile health solutions for both undernutrition and obesity prevention (Ulfa et al., 2022; Kustiawan et al., 2022).

1.1.1 Thematic findings

A narrative synthesis was undertaken due to the considerable heterogeneity observed in study designs, populations, intervention modalities, and outcome measures across the included studies. Thematic groupings were applied to facilitate qualitative comparison, particularly based on intervention type—namely, mobile applications focused on nutrition education, developmental monitoring, or combined approaches targeting both domains. This approach enabled the identification of patterns and

divergences in the reported effectiveness and design of mHealth interventions aimed at improving early childhood nutrition and development outcomes.

Across the body of literature, three dominant types of digital interventions emerged. The first group comprised nutrition-focused educational apps targeted at parents or caregivers. These included MyKid'sNutrition, developed to enhance maternal knowledge and practices related to childhood undernutrition in Iran (Hojati et al., 2023), and the TreC-LifeStyle app in Italy, which promoted healthy eating among overweight children using evidence-based Mediterranean diet principles (Gabrielli et al., 2017). Similarly, a quasi-experimental study in Iran used a mobile application to educate mothers on complementary feeding practices, resulting in statistically significant improvements in key anthropometric indicators such as weight-for-age and length-for-age Z-scores (Mousavi Ezmareh et al., 2024).

The second category comprised apps that adopted broader developmental or lifestyle behavior frameworks. For example, Thompson et al. (2025) used a mixed-methods design to incorporate parental input into an app promoting healthy routines, including diet, sleep, and physical activity. Likewise, BabyThrive—a bilingual mobile game developed for Nigerian teenage mothers—showed significant gains in maternal knowledge of exclusive breastfeeding and overall infant feeding practices (Sosanya et al., 2024). In both studies, high levels of usability and parental satisfaction were reported, indicating that contextual and culturally sensitive design significantly enhances user engagement and perceived value.

The third thematic cluster involved interventions with integrated or multi-outcome targets. These include the study by Nezami et al. (2022), which evaluated the dietary impacts of a mobile self-monitoring app among overweight parents and their children. The app's functionality—combining dietary logging, feedback loops, and educational content—was associated with improvements in both adult and child dietary intake, suggesting the potential for intergenerational influence. In Malaysia, Er et al. (2023) proposed a cluster randomized trial to test a multicomponent intervention including mHealth education and personalized medical nutrition therapy for pregnant women, with gestational weight gain and quality of life as primary outcomes.

Further insights were gained from synthesis-based and exploratory studies. The systematic review protocol by Perego et al. (2020) aimed to classify mHealth interventions for pediatric overweight management, laying groundwork for future trials by establishing outcome hierarchies and classification frameworks. In contrast, Ulfa et al. (2022) conducted a bibliometric analysis of dietary self-monitoring apps, revealing key implementation trends, such as real-time tracking and the use of algorithm-based feedback. Similarly, Kustiawan et al. (2022) synthesized evidence from twelve studies on growth monitoring apps for undernourished and overweight children, highlighting the widespread use of tracking features and educational content to support early intervention and behavioral change.

Across the studies, intervention delivery was predominantly smartphone-based, leveraging diverse functionalities such as food logging, growth monitoring, multimedia education, and gamified engagement. The apps varied considerably in their technological complexity—from static information modules to interactive, bilingual gaming platforms—and in their underlying behavioral change strategies, which included self-monitoring, personalized feedback, and goal setting. Implementation strategies also differed, ranging from formative user-centered design (Gabrielli et al., 2017) to large-scale randomized trials (Hojati et al., 2023; Er et al., 2023) and structured validation methods (Sosanya et al., 2024).

1.1.2 Risk of Bias assessment

To evaluate the methodological rigor of the included studies, the Joanna Briggs Institute (JBI) Critical Appraisal Tools were applied according to each study's design. Each study was independently

assessed by two reviewers, with a focus on key domains including participant selection, measurement validity, management of confounding variables, and the appropriateness of statistical analysis. Although no studies were excluded solely based on methodological quality, the JBI assessments informed the strength of the synthesized findings and the interpretability of evidence across study types.

Randomized controlled trial protocols such as those by Hojati et al. (2023) and Er et al. (2023) met the majority of JBI criteria related to internal validity and design clarity, including randomization procedures, clearly defined inclusion criteria, and proposed use of appropriate statistical models (e.g., ANCOVA and generalized linear mixed models). However, as protocols, they had not yet demonstrated execution, leaving issues such as attrition and intervention fidelity unassessed. The completed RCT by Nezami et al. (2022) demonstrated strong methodological adherence, with validated tools, baseline comparability, and blinding of outcome assessment, resulting in low risk of bias across most domains.

Quasi-experimental studies such as that by Mousavi Ezmareh et al. (2024) generally satisfied core JBI criteria concerning intervention clarity, comparability of groups, and outcome measurement. Nonetheless, limited detail on potential confounding control, and lack of blinding of outcome assessors presented moderate risk of detection and performance bias. Despite these limitations, the study provided consistent, statistically significant results that supported internal validity.

Formative and user-centered designs, including Gabrielli et al. (2017) and Thompson et al. (2025), provided valuable insights into acceptability and usability but posed limitations in methodological robustness. These studies were not designed for causal inference, and while they adhered to ethical and conceptual transparency, they lacked statistical controls for bias and relied on small, non-random samples. As such, these were judged to be at higher risk of selection and reporting bias, limiting generalizability.

App development and validation studies, such as Sosanya et al. (2024), incorporated mixed methods and were assessed using JBI's checklist for quasi-experimental and cross-sectional designs. The study demonstrated high methodological quality in terms of clear objectives, appropriate outcome measures, and triangulation of data sources, although the lack of blinding and reliance on self-reported outcomes were noted as potential bias risks.

Systematic reviews and bibliometric analyses (e.g., Perego et al., 2020; Kustiawan et al., 2022; Ulfa et al., 2022) were assessed using JBI's checklists for reviews and analytical studies. While these provided comprehensive overviews of intervention typologies and research trends, not all adhered to transparent inclusion criteria or presented critical appraisals of the included studies, limiting the depth of synthesized conclusions. Perego et al. (2020), however, included robust methodological plans (e.g., GRADE, Trial Sequential Analysis), increasing the anticipated reliability of future findings.

In summary, the application of the JBI Critical Appraisal Tools revealed overall moderate to high methodological quality across the included studies. While several studies exhibited minor risks of bias due to design limitations or incomplete reporting, the majority used appropriate outcome measures, population targeting, and analytical methods. These assessments underscored the emerging robustness of the evidence base for mobile health applications in early childhood nutrition and development, particularly when interventions were rigorously evaluated through randomized or controlled study designs. Future research would benefit from enhanced transparency, larger sample sizes, and standardized reporting to strengthen the credibility and reproducibility of digital health interventions in this domain.

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Table 1. **Characteristics of included studies and summary of findings**

Author(s)	Year of Publication	Country of Study	Study Design	Population Characteristics	Details of the Digital Intervention	App Functionalities and Targeted Behaviors	Outcomes Related to Child Nutrition and Early Development	Implementation Processes	User Engagement Levels	Technological Features
Paolo Perego, Rajeeb Rashid, Christian Gluud, Janus C. Jakobsen, Giuseppe Andreoni, Inge Lissau	2020	Not specified (authors from Denmark and Italy, suggesting a European focus)	Systematic review protocol for randomized clinical trials	Children and adolescents aged 0–18 years with all degrees of overweight, including obesity and morbid obesity	Review to compare different categories of mHealth applications for managing overweight in children	Apps will be classified by type of intervention, use of measurement devices, coaching components, and reward systems	Primary outcomes include BMI z-score, quality of life, and serious adverse events; secondary outcomes include body weight, self-efficacy, anxiety, depression, and non-serious adverse events	Study inclusion, data extraction, and risk of bias assessment conducted by at least two reviewers; use of GRADE and Trial Sequential Analysis for quality and error control	Not applicable as this is a protocol, not a primary intervention study	Use of mobile technologies incorporating coaching, rewards, and monitoring; technologies not yet analyzed in this protocol
Ali Hojati, Sogol Alesaeidi, Saeideh	2023	Iran	Randomized controlled	Mothers of preschool children (aged 2–6	MyKid'sNutrition is a smartphone-based app	The app includes educational content on	Improvements in children's growth	116 participants randomized into	Anticipated to be high due to	Smartphone-based platform delivering

Izadi, Alireza Nikniaz, Mahdieh Abbasalizad Farhangi			trial (study protocol)	years) with undernutrition	developed to improve maternal nutritional knowledge and practices concerning childhood undernutrition	healthy eating, managing appetite loss, growth assessment, and guidance on mother–child interaction	indicators and mothers' nutritional knowledge, attitudes, and practices	intervention (app + usual care) and control (usual care only) groups; outcome differences will be assessed	smartphone accessibility; actual engagement data not yet reported	multimedia education, feeding tips, and growth monitoring features
Silvia Gabrielli, Marco Dianti, Rosa Maimone, Marta Betta, Lorena Filippi, Monica Ghezzi, Stefano Forti	2017	Italy	Formative evaluation study using a user-centered design (UCD) approach	Six families with overweight children aged 7–12 years	TreC-LifeStyle is a mobile nutrition education app developed with input from pediatricians, nutritionists, and behavior change experts.	Food logging, behavior monitoring, and delivery of educational content based on the Mediterranean diet and food pyramid	Improved parental awareness of child eating behavior, high compliance; some limitations in monitoring features	6-week usage period with ongoing feedback used to refine app features	High usability and compliance reported among all families	Mobile logging, coaching, dietary tracking, and evidence-based nutrition education content
Maria Ulfa, Winny Setyonugroho, Tri Lestari, Esti Widiasih, Anh Nguyen Quoc	2022	Not specified (global bibliometric analysis with major contributions from China)	Descriptive-analytic bibliometric analysis	Not applicable (analysis of published literature, not a participant-based study)	This study reviewed 205 publications on dietary self-monitoring apps, focusing on identifying implementati	Apps allow users to log meals, assess dietary intake, track calories, and support lifestyle improvemen	While not focused specifically on child nutrition, findings highlight behavior change interventions	Articles were selected from Scopus; analysis conducted using VOSviewer and NVivo to extract	Not directly assessed; inferred through app features like real-time tracking	Apps integrate real-time dietary tracking, calorie calculation, and algorithm-based

					on strategies and thematic research trends.	ts and disease management.	through mobile self-monitoring tools with relevance to overall health.	research clusters and trends.	and automated feedback.	nutrition feedback systems.
Fariba Mousavi Ezmareh, Zahra Bostani Khalesi, Fatemeh Jafarzadeh Kenarsari, Saman Maroufizadeh	2024	Iran	Quasi-experimental study with control group	86 mothers of infants, divided into intervention (n=43) and control (n=43) using multistage sampling	Mobile phone application used to deliver complementary feeding education to mothers over a 3-month period	App provided educational content on infant nutrition and complementary feeding practices tailored for Iranian mothers	Significant improvements in infant weight-for-age, weight-for-length, and length-for-age Z-scores in the intervention group after 3 months	Pre- and post-intervention measurements taken; statistical analysis included t-tests, chi-square, and ANCOVA	Engagement inferred through follow-up completion; exact usage metrics not reported	Mobile-based education platform with static and interactive modules for maternal learning
Mercy Eloho Sosanya, Folake Olukemi Samuel, Sadia Bashir, Victoria Osariemen Omoera, Jeanne H Freeland-Graves	2024	Nigeria	App development and validation study using crossover design and usability testing	90 teenage mothers from rural areas in Abuja, Nigeria, most of whom were married and had no personal income	Development of BabyThrive, a mobile gaming app designed to train teenage mothers in appropriate infant and young child feeding (IYCF) practices	App delivers IYCF training through interactive 2D game-based learning in both English and Hausa; features include behavioral simulations	Significant improvements in knowledge of exclusive breastfeeding and total IYCF knowledge compared to verbal training; statistically significant correlations	Used focus groups, expert validation, crossover experimental design, and quantitative surveys (Teen Moms Child Feeding Questionnaire for Sub-	Over 80% reported high usability and satisfaction with the app; average quality rating was 4.3 out of 5.0	Offline-capable 2D game; bilingual interface (English and Hausa); supports interactive, gamified education tailored to low-

						and nutrition education	were observed	Saharan Africa)		resource settings
Jessica R. Thompson, Summer J. Weber, Shelagh A. Mulvaney, Susanna Goggans, Madeline Brown, Anthony Faiola, Lynn Maamari, Pamela C. Hull	2025	United States (Kentucky)	Convergent mixed methods study (concept mapping and semi-structured interviews)	30 parents or guardians of preschool children (ages 2–5 years)	Explored parental needs and preferences to guide the design of a mobile app for promoting healthy lifestyle behaviors in preschoolers	App features included goal tracking, healthy eating tips, child-friendly recipes, notifications, and guidance on sleep and media use	Parents prioritized general health, routine-setting, and healthy eating. Conceptual clusters informed content development: Creating Healthy Eating Habits, Forming Boundaries, and Building Good Relationships	Combined web-based concept mapping, Likert ratings, and thematic analysis from interviews. Results triangulated to inform design	High interest in simple, engaging, and parent-friendly features. Usability expectations clearly expressed by participants	Conceptual features include habit tracking, family-oriented recipes, notifications, and guided goal setting within a mobile interface
Ying Ting Er, Yoke Mun Chan, Zalilah Mohd Shariff, Habibah Abdul Hamid, Zulfitri	2023	Malaysia	Dietitian-led cluster randomized controlled trial (protocol paper)	294 pregnant women recruited in their first or second trimester and	mHealth-based intervention, with three arms: mHealth only, mHealth plus personalized nutrition	Educational app delivering content on prenatal nutrition, physical activity, psychological wellbeing,	Primary outcome is gestational weight gain (GWG); secondary outcomes include diet quality, sleep quality,	Participants followed prospectively at three time points using structured questionnaires and anthropomet	User engagement will be evaluated as part of ongoing trial follow-up; not yet reported in	mHealth app platform with structured educational modules and integration with

'Azuan Mat Daud, Heng Yaw Yong				followed until delivery	therapy, and control group	sleep, and lifestyle behaviors	physical activity, and quality of life	ric assessments; generalized linear mixed models will analyze the data	the protocol	medical nutrition therapy (in one arm)
Brooke T. Nezami, Heather M. Wasser, Deborah F. Tate	2022	United States	Randomized controlled trial	Adults with overweight or obesity who had a child aged 2–12 years living at home	A smartphone-based intervention delivering lessons, text messages, personalized feedback, and self-monitoring for parents	Diet tracking (calorie or "red" food monitoring), personalized messages, weekly feedback, physical activity and weight self-monitoring	Parent dietary improvements were associated with positive changes in child dietary intake, including calories and grain types	Delivered over 6 months with 2 dietary recall assessments (baseline and post-intervention) for both parents and children	Higher engagement (e.g., meeting dietary goals) correlated with improved dietary intake and lower caloric consumption in parents	Mobile app with personalized messaging, lesson modules, and feedback loop integrated for monitoring and education
Theresia Chrisanthy Kustiawan, Siti Rahayu Nadhiroh, Roziana Ramli, Chaniphun Butryee	2022	Multi-country (systematic review)	Systematic literature review	Not specific; studies included parents and health workers dealing with undernutrition or	Use of mobile apps to monitor growth in children with poor nutritional status	Monitoring growth, education for parents and health workers, weight tracking, nutrition guidance	Improved growth outcomes in undernourished and overweight children, increased parental and	Synthesized from 12 studies, varied strategies; most aimed at early detection and monitoring	Generally positive, mobile apps increased motivation and awareness	Smartphone-based apps, with features for tracking, alerts, and user interaction

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				obesity in children			provider knowledge			

4. DISCUSSION

This scoping review aimed to evaluate the effectiveness of mobile applications (mHealth interventions) in delivering nutrition education and monitoring early childhood development among parents and caregivers of children aged 0–5 years. Employing the Joanna Briggs Institute framework and reported in accordance with PRISMA-ScR guidelines, the review synthesized a diverse body of literature to identify thematic trends, assess methodological quality, and highlight implications for practice and future research.

The analysis revealed three dominant thematic clusters in the current literature: nutrition education-focused apps, behaviorally oriented or developmental apps, and integrated interventions targeting multiple domains. Nutrition-focused apps, such as MyKid'sNutrition (Hojati et al., 2023). and TreC-LifeStyle aimed to improve caregivers' knowledge and practices around childhood nutrition, with documented effects on dietary habits and anthropometric outcomes (Mousavi Ezmareh et al., 2024) These studies underscore the effectiveness of targeted education delivered through familiar and accessible platforms such as smartphones, particularly when grounded in culturally relevant dietary frameworks.

Apps with broader behavioral or developmental aims, including BabyThrive (Sosanya et al., 2024) and the lifestyle intervention developed by Thompson et al. (2025), emphasized holistic child-rearing behaviors such as sleep hygiene, feeding practices, and media use. Notably, these interventions reported high user engagement and acceptability, especially when content was bilingual or culturally adapted. This underscores the importance of localized design and inclusive features in fostering uptake, particularly among marginalized or resource-limited populations.

Interventions that integrated multiple outcome domains appeared particularly promising. (Nezami et al., 2022) demonstrated intergenerational dietary improvements via a mobile app that engaged both parents and children through goal setting and self-monitoring. Similarly, the trial protocol by (Er et al., 2023)introduced a tiered intervention model combining general mHealth education with personalized nutritional therapy. These multidimensional approaches align with evidence that addressing both knowledge and behavior concurrently may be more effective in producing sustainable changes in health outcomes.

The inclusion of exploratory and synthesis-based studies added valuable context. (Perego et al., 2022) laid a foundation for future clinical trials by offering a structured framework to classify mHealth interventions for pediatric obesity, while bibliometric reviews by (Perego et al., 2022) and (Kustiawan et al., 2022) revealed common technological strategies—such as real-time feedback and automated tracking—emerging across the mHealth landscape. These insights highlight not only innovation trends but also reveal the challenges of standardizing features and outcomes across heterogeneous digital tools.

Despite these promising findings, several gaps and limitations persist in the literature. First, outcome heterogeneity remains a significant barrier to meta-analytical synthesis. Studies varied widely in design, duration, target populations, and outcome metrics, ranging from anthropometric Z-scores to knowledge assessments and engagement indices. Few interventions reported long-term follow-up data, limiting understanding of sustainability and durability of impact. Moreover, while some studies employed robust methodological designs, including randomized controlled trials and validated outcome tools, others relied on small samples, descriptive analyses, or lacked control groups, which limits generalizability.

In terms of risk of bias, while most studies demonstrated reasonable rigor in their implementation, potential weaknesses were observed in blinding procedures, handling of confounders, and reporting of adherence metrics. For instance, many studies inferred user engagement based on retention or qualitative feedback rather than providing app usage analytics. Additionally, although the JBI Critical

Appraisal Tools were applied in this review, varying methodological quality across study designs complicates direct comparison and should temper conclusions regarding effectiveness.

From a policy and implementation perspective, the findings suggest strong potential for mHealth tools to serve as scalable, low-cost solutions in both high-income countries and low- and middle-income countries (LMICs). In LMICs, apps like BabyThrive (Sosanya et al., 2024) demonstrate how culturally adapted, gamified content can improve caregiver knowledge and practices despite infrastructural constraints. Conversely, studies from high-income contexts, such as the United States and Europe, illustrate how digital tools can complement existing health systems by enhancing personalization and self-monitoring features.

To advance the field, future research should prioritize methodological consistency, including standardized outcome reporting, validated assessment tools, and longer follow-up periods to assess sustained behavior change and developmental impact. Comparative effectiveness trials are also needed to determine which design elements—such as gamification, personalization, or integration with clinical services—most influence outcomes. Furthermore, implementation science frameworks should be employed to evaluate scalability, cost-effectiveness, and equity of access across diverse settings.

5. CONCLUSIONS

While evidence remains emergent, this review provides a strong rationale for the continued development and evaluation of mobile applications as tools to support parental nutrition education and early child development monitoring. Interventions that are theory-driven, culturally tailored, and co-designed with end users appear most likely to achieve meaningful impact. Policymakers and program developers should consider integrating mHealth solutions into maternal and child health strategies, particularly where traditional service delivery is constrained.

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REFERENCES

Black, M. M., Walker, S. P., Fernald, L. C. H., Andersen, C. T., DiGirolamo, A. M., Lu, C., McCoy, D. C., Fink, G., Shawar, Y. R., Shiffman, J., Devercelli, A. E., Wodon, Q. T., Vargas-Barón, E., & Grantham-McGregor, S. (2017). Early childhood development coming of age: Science through the life course. *The Lancet*, *389*(10064), 77–90. https://doi.org/10.1016/S0140-6736(16)31389-7Black et al., 2017

Er, Y. T., Chan, Y. M., Shariff, Z. M., Hamid, H. A., Mat Daud, Z. A., & Yong, H. Y. (2023). Dietitian-led cluster randomised controlled trial on the effectiveness of mHealth education on health outcomes among pregnant women: A protocol paper. *BMJ Open*, *13*(11), e075745. https://doi.org/10.1136/bmjopen-2023-075745

Free, C., Phillips, G., Watson, L., Galli, L., Felix, L., Edwards, P., Patel, V., & Haines, A. (2020). The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: A systematic review. *PLOS Medicine*, *10*(1), e1001362. https://doi.org/10.1371/journal.pmed.1001362

Gabrielli, S., Dianti, M., Maimone, R., Betta, M., Filippi, L., Ghezzi, M., & Forti, S. (2017). Design of a mobile app for nutrition education (TreC-LifeStyle) and formative evaluation with families of overweight children. *JMIR mHealth and uHealth, 5*(4), e48. https://doi.org/10.2196/mhealth.7080

Alesaeidi, S., Izadi, S., Nikniaz, A., & Abbasalizad Farhangi, M. (2023). *MyKid'sNutrition mobile application trial: A randomized controlled trial to promote mothers' nutritional knowledge and nutritional status of preschool children with undernutrition—a study protocol*. Trials, 24, Article 528. https://doi.org/10.1186/s13063-023-07503-w

Joanna Briggs Institute. (2020). *JBI manual for evidence synthesis*. https://synthesismanual.jbi.global

Kustiawan, T. C., Nadhiroh, S. R., Ramli, R., & Butryee, C. (2022). Use of mobile app to monitoring growth outcome of children: A systematic literature review. *Journal of Education and Health Promotion*, *11*, 397. https://doi.org/10.4103/jehp.jehp_1583_21

Lee, S. H., Nurmatov, U. B., Nwaru, B. I., Mukherjee, M., Grant, L., & Pagliari, C. (2022). Effectiveness of mHealth interventions for maternal, newborn and child health in low– and middle–income countries: Systematic review and meta–analysis. *Journal of Global Health*, *12*, 04046. https://doi.org/10.7189/jogh.12.04046

Mousavi Ezmareh, F., Bostani Khalesi, Z., Jafarzadeh Kenarsari, F., & Maroufizadeh, S. (2024).The impact of complementary feeding education for mothers using mobile phone applications on the anthropometric indices of Iranian infants. *BMC Pediatrics, 24*, Article 176. https://doi.org/10.1186/s12887-024-04447-5

T., Wasser, H. M., & Tate, D. F. (2022). Parent and child dietary changes in a 6-month mobile-delivered weight loss intervention with tailored messaging for parents. *Appetite*, *178*, 106173. https://doi.org/10.1016/j.appet.2022.106173

Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systematic Reviews*, 5(1), 210. https://doi.org/10.1186/s13643-016-0384-4

J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, 372, n71. https://doi.org/10.1136/bmj.n71

Rashid, R., Gluud, C., Jakobsen, J. C., Andreoni, G., & Lissau, I. (2020). Comparison of different mobile health applications for intervention in children and adolescents with overweight: A protocol for systematic review with meta-analysis and trial sequential analysis. *BMJ Open*, *10*(12), e039995. https://doi.org/10.1136/bmjopen-2020-039995

Sosanya, M. E., Samuel, F. O., Bashir, S., Omoera, V. O., & Freeland-Graves, J. H. (2024). A mobile gaming app to train teenage mothers on appropriate child feeding practices: Development and validation study. *JMIR Pediatrics and Parenting, 7*(1), e52141. https://doi.org/10.2196/52141

Thompson, J. R., Weber, S. J., Mulvaney, S. A., Goggans, S., Brown, M., Faiola, A., Maamari, L., & Hull, P. C. (2025). Parental perceptions of priorities and features for a mobile app to promote healthy lifestyle behaviors in preschool children: Mixed methods evaluation. *JMIR Pediatrics and Parenting, 8*, e65451. https://doi.org/10.2196/65451

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., ... Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine*, *169*(7), 467–473. https://doi.org/10.7326/M18-0850

Ulfa, M., Setyonugroho, W., Lestari, T., Widiasih, E., & Nguyen Quoc, A. (2022). Nutrition-related mobile application for daily dietary self-monitoring. *Journal of Multidisciplinary Healthcare, 15*, 2093–2103. https://doi.org/10.2147/JMDH.S375910

UNICEF. (2023). *The state of the world's children 2023: For every child, nutrition*. https://www.unicef.org/reports/state-worlds-children-2023

World Health Organization. (2021). *Nurturing care framework for early childhood development: A framework for helping children survive and thrive to transform health and human potential*. https://www.who.int/publications/i/item/9789241514064