NutriSmart: Jurnal Gizi dan Teknologi Pangan

https://fikesunras.ac.id/index.php/NutriSmart
NutriSmart Vol 2(2) 2026 Pages 141-153

Effectiveness of Smartphone Application-Based Nutrition Education for Parents on Changes in Children's Eating Behaviour

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Article History:
Submitted and Pre-review: 9 July 2026
Review: 16 July 2026
Copy Edit: 28 July 2026
Production: 29 July 2026
Published: 31 July 2026

DOI: https://doi.org/10.64146/sw8ztj73

Abstract

Sub-optimal eating behavior, such as picky eating, is still a determining factor in nutritional problems among preschool-aged children in Bengkulu City, while conventional nutrition education has limited reach. This research aims to analyze the effectiveness of smartphone application-based nutrition education for parents in changing the eating behavior of children aged 3–6 years in Bengkulu City. The methodology used a quasi-experimental pretest-posttest design with a control group implemented in two community health centers, with a total of 86 parents recruited purposively and allocated based on service area into the intervention group (n=43), which received education for eight weeks via the NutriAnak application based on the Health Belief Model, and the control group (n=43), which received conventional counseling and print media. Children's eating behavior was measured using the Children's Eating Behavior Questionnaire (CEBQ) and analyzed using paired t-test and independent t-test ($p<0,05$). The results for the intervention group, food aversion decreased significantly ($\Delta=-0,68\pm0,42$; $p<0,001$) and enjoyment of food increased significantly ($\Delta=0,54\pm0,38$; $p<0,001$). Changes in scores in the intervention group were significantly greater than those in the control group across all eight CEBQ subscales ($p<0,05$), with effect sizes of 0,74–1,27. In conclusion, smartphone application-based nutrition education effectively improves children's eating behavior by strengthening parental feeding practices, thereby supporting its integration into public health nutrition programs.

Keywords: Nutrition education, smartphone applications, children's eating behaviour, parents, mHealth

How to cite this article:
Daryati, M., Anggraini, R., & Sari, J. P. (2026). Effectiveness of Smartphone Application-Based Nutrition Education for Parents on Changes in Children's Eating Behaviour. Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 2(2), 140-152. https://doi.org/10.64146/sw8ztj73

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E-ISSN: 3110-4959

INTRODUCTION

Nutritional problems in preschool children are a global public health issue that requires comprehensive and sustainable treatment. The World Health Organization estimates that around 150,2 million children under the age of five will experience stunting in 2024, with the highest prevalence in Southeast Asia and Sub-Saharan Africa (UNICEF et al., 2023; World Health Organization, 2024). In Indonesia, the 2023 Indonesian Health Survey recorded a stunting prevalence of 21.5%, which shows that one in five children under five still experiences linear growth disorders due to chronic malnutrition (Kementerian Kesehatan RI, 2023; W. Rahmawati et al., 2025). This condition is exacerbated by the double burden of malnutrition, where the problems of undernutrition and overnutrition occur simultaneously in the same population (Dewi et al., 2024; Fahmida et al., 2024; Harjadinta & Susanty, 2025).

Bengkulu Province faces similar challenges in handling child nutrition problems. Data from the 2022 Indonesian Nutrition Status Survey (SSGI) shows that the prevalence of stunting in Bengkulu Province is 19.8%, decreasing from 22,1% in 2021 (Dinas Kesehatan Provinsi Bengkulu, 2023; Nugroho et al., 2023). Even though there has been a decline, this figure is still above the national target of 14% set in the 2020-2024 National Medium Term Development Plan (RPJMN). Specifically for Bengkulu City, the prevalence of stunting was recorded at 12.8% based on the 2022 SSGI. The distribution is uneven among health centre areas, with several areas still having a high prevalence (Prastiwi & Hermawan, 2023; R. Rahmawati et al., 2024).

Children's eating behaviour that is not optimal is one of the important determinants of nutritional problems. Picky eating or food fussiness behaviour, which is characterised by rejection of certain foods and a limited variety of foods consumed, has a fairly high prevalence in preschool children in Indonesia (Hardini & Wirjatmadi, 2024; Samuel et al., 2023). Research shows that children with picky eating behaviour have a higher risk of experiencing micronutrient deficiencies and stunted growth than children with normal eating behaviour (Brown et al., 2022; Cahyani, 2025; Scaglioni et al., 2022). Children's eating behaviour is influenced by various factors, including parental feeding practices, the eating environment at home, and exposure to various types of food from an early age (Eka Daryati & Sadiana, 2025; Norton et al., 2023).

Parents have a central role in shaping children's eating behaviour through feeding practices that are applied in everyday life. Responsive feeding practices, which emphasize sensitivity to children's hunger and satiety cues, have been shown to contribute positively to the development of healthy eating behaviour and optimal regulation of energy intake, whereas non-responsive feeding practices such as force-feeding, excessive restriction, or the use of food as a reward can exacerbate picky eating behaviour and increase the risk of eating disorders later in life (Carbonneau et al., 2023; Edwards et al., 2024; Pickard et al., 2025). Interventions targeting increasing parental knowledge

https://doi.org/10.64146/sw8ztj73

and skills in feeding practices are a promising strategy for improving children's feeding behaviour (M. Daryati et al., 2026).

Nutrition education is an important component in efforts to prevent and treat children's nutritional problems. Educational approaches grounded in the Health Belief Model, a behaviour change framework centred on perceived susceptibility, severity, benefits, and barriers, have been shown to be effective in changing knowledge, attitudes, and practices related to nutrition (Siyou, 2025). Implementation of conventional nutrition education, however, often faces obstacles such as limited time, reach, and programme sustainability Meshkovska et al 2023). which collectively reduce the long-term impact of face-to-face dietary interventions on children's eating behaviour. The development of digital technology, especially smartphones, opens up new opportunities to overcome these obstacles through a more flexible and widely accessible mobile health (mHealth) approach (Rachmah et al., 2023; Riazi et al., 2024; Seid et al., 2024)

Smartphone penetration in Indonesia has reached very high levels, with more than 73% of residents having access to smartphones by 2023 (Asosiasi Penyelenggara Jasa Internet Indonesia, 2024). This condition provides an opportunity to optimise the use of smartphone applications as an innovative and interactive nutrition education medium. Various international studies have demonstrated the potential of smartphone applications in supporting health behaviour change, including eating behaviour and physical activity (Heerman et al., 2024; Talens et al., 2025). Smartphone apps enable the delivery of personalised information, automatic reminders, progress tracking, and two-way interactions that can increase user engagement and motivation (Cox et al., 2023; M. E. Daryati et al., 2026; Milne-Ives et al., 2024).

Smartphone app-based interventions targeting parents have shown promising results in the context of preventing and treating childhood obesity and improving feeding practices (Hayek et al., 2025; Pereira et al., 2021). A recent systematic review showed that web-based interventions targeting parents can increase responsive feeding practices and reduce the use of non-responsive feeding strategies, but empirical evidence regarding the effectiveness of smartphone application-based interventions in the Indonesian context, particularly in changing children's eating behaviour through parental empowerment, is still limited (Wang et al., 2024).

Bengkulu City, no study has specifically evaluated the effectiveness of smartphone application-based nutrition education in changing children's eating behaviour. This gap is substantively important because the city's high prevalence of childhood malnutrition, limited access to trained nutritionists in peripheral health centres, and distinct local dietary patterns dominated by high-carbohydrate staples create contextual conditions that may moderate intervention outcomes differently from those reported in other Indonesian cities (Flores-Vázquez et al., 2024; Lombamo et al., 2024)

https://doi.org/10.64146/sw8ztj73

The majority of nutrition education interventions conducted to date still rely on conventional approaches such as face-to-face counselling and print media. Given the high penetration of smartphones among young mothers and the need for more innovative and sustainable approaches, the development and evaluation of smartphone application-based interventions is highly relevant. This study therefore aims to analyse the effectiveness of smartphone application-based nutrition education for parents on changes in the eating behaviour of children aged 3–6 years in Bengkulu City.

METHODOLOGY

Types of research

A quantitative approach with a pretest–posttest control group quasi-experimental design was applied in this study. The choice of design was based on its ability to evaluate the effectiveness of the intervention through the presence of a comparison group. Because implementing full randomisation is difficult to achieve in a community setting, this design represents the most methodologically rational option(Murimi et al., 2018).

Time and Place of Research

The research was carried out at the Sawah Lebar Community Health Centre and the Nusa Indah Community Health Centre, Bengkulu City, which have homogeneous characteristics. Location determination was decided purposively by considering the availability of health infrastructure and access to digital technology. The series of data collection and intervention took place over twelve weeks in the period from March to June 2025.

Population and Sample

All parents registered at the posyandu in the working areas of the two health centres who had children aged three to six years were defined as the study population. Inclusion criteria comprised ownership of an Android or iOS smartphone, willingness to participate throughout the intervention period, and a child in healthy condition without chronic diet-related diseases. Exclusion criteria included cognitive or hearing impairment in parents, a history of multiple food allergies in children, and plans to relocate the family domicile.

The sample size was determined using the hypothesis-test formula for the difference between two means. The calculation parameters included a statistical power of 80%, a significance level of 5%, and an estimated effect size of 0,65 derived from Pereira et al., 2021, whose intervention similarly employed a mobile technology-based nutrition education programme targeting dietary behaviour change in school-age children, making the reported effect size a reasonable approximation for the present study's population and outcome measures. After accounting for an anticipated 10% dropout, the final sample size reached 86 parents.

https://doi.org/10.64146/sw8ztj73

Group allocation was based on puskesmas catchment-area boundaries to prevent contamination between interventions, constituting a non-randomised cluster assignment rather than true randomisation. This pragmatic strategy may introduce selection bias arising from unmeasured sociodemographic or environmental differences across areas, a limitation to be considered when interpreting the findings. The Sawah Lebar Community Health Centre served as the intervention group and the Nusa Indah Community Health Centre as the control group. Data were analysed using a paired t-test for within-group comparisons and an independent t-test for between-group comparisons at a significance level of 0,05.

Data Collection Techniques and Instrument Development

The data collection process relied on structured interviews regarding respondent characteristics and on the completion of questionnaires in the pre- and post-intervention phases. The intervention group received nutrition education via the NutriAnak smartphone application, which is based on the Health Belief Model framework. Application features included interactive educational modules, video demonstrations of food preparation, a consumption-recording system, schedule reminders, and discussion forums. Content development involved collaboration with three nutrition experts, two early childhood education experts, and two information technology experts, who evaluated each item using a structured content validity assessment; the resulting content validity index met the acceptable threshold prior to application deployment (Riazi et al., 2024; Lombamo et al., 2024).

The control group received conventional face-to-face counselling twice and used print media in the form of leaflets and posters. Children's eating behaviour was measured using the Indonesian version of the Children's Eating Behaviour Questionnaire (CEBQ), adapted through a standardised cross-cultural translation procedure (forward translation, back translation, and expert review) and subsequently validated for an Indonesian population. The questionnaire contains 35 five-point Likert-scale statements assessing eight eating behaviour subscales and showed good reliability (Cronbach's alpha 0,72–0,91).

Data Analysis Techniques

Statistical data processing was carried out with the help of SPSS version 26.0 software. The respondent profile is described descriptively through a frequency distribution, percentage, mean value, and standard deviation. Checking the equality of characteristics between groups was carried out using the chi-square test on categorical data and the independent t-test on numerical data. Prior to hypothesis testing, the Shapiro-Wilk test was applied to assess the normality of the data distribution, and because the assumption of normality was satisfied, the evaluation of intervention effectiveness was analysed using a paired t-test to examine the difference in pre-test and post-test scores. An independent t-test was then applied to compare the difference in score changes between the two groups. The limit of statistical significance is set at p less than 0,05.

https://doi.org/10.64146/sw8ztj73

RESULTS AND DISCUSSION

RESULTS

Of the 86 parents recruited, all completed the intervention programme, yielding a retention rate of 100%. Although complete retention is uncommon in longitudinal studies and warrants cautious interpretation, several procedural factors may account for it. Participant engagement was sustained through weekly follow-up contact by trained enumerators and posyandu cadres, automated in-app and WhatsApp reminders, the brief and flexible nature of the mobile modules that allowed parents to participate at their convenience, and the relatively short eight-week intervention period. In addition, the purposive recruitment of parents who had already expressed willingness to participate may have selected for a highly motivated sample. Nevertheless, the possibility of reporting bias, whereby participants were retained administratively without actively using the application, cannot be fully excluded; application engagement logs (a mean of 4,2 accesses per week) were therefore used to corroborate genuine participation.

The demographic characteristics of respondents in both groups are presented in Table 1. The analysis showed no significant differences in demographic characteristics between the intervention and control groups (p>0,05), indicating that the two groups had a comparable baseline.

Table 1. Demographic Characteristics of Respondents

Characteristics	Intervention (n=43)	Control (n=43)	P-value
Maternal age (years), mean ± SD	31,4±4,8	30,9±5,1	0,642
Mother's Education, n (%)			0,517
- Elementary/middle school	8 (18,6)	10 (23,3)	
- SMA/SMK	21 (48,8)	22 (51,2)	
- College	14 (32,6)	11 (25,6)	
Mother's Working Status, n (%)			0,384
- Work	18 (41,9)	14 (32,6)	
- Doesn't work	25 (58,1)	29 (67,4)	
Family Income, n (%)			0,462
- < Minimum wage	19 (44,2)	22 (51,2)	
- ≥ Minimum wage	24 (55,8)	21 (48,8)	
Child Age (years), mean±SD	4,3±1,1	4,5±1,0	0,378
Child Gender, n (%)			0,829
- Man	22 (51,2)	21 (48,8)	
- Woman	21 (48,8)	22 (51,2)	

Note: SD = Standard Deviation; UMR = Regional Minimum Wage

The results of measuring children's eating behaviour using CEBQ before and after intervention in both groups are presented in Table *2*. At baseline, there were no significant differences in CEBQ scores between the intervention and control groups on all subscales (p>0,05). After the

https://doi.org/10.64146/sw8ztj73

intervention, the intervention group showed significant changes in several eating behaviour subscales.

Table 2. Comparison of CEBQ Scores Before and After Intervention

CEBQ subscales	Intervention Group (n=43)			Control Group (n=43)		
	Pre	Post	P*	Pre	Post	P*
Food Fussiness	3,42±0,58	2,74±0,51	<0,001	3,38±0,62	3,21±0,59	0,087
Enjoyment of Food	2,86±0,49	3,40±0,44	<0,001	2,91±0,52	3,02±0,48	0,124
Food Responsiveness	2,78±0,56	3,12±0,48	0,003	2,81±0,53	2,89±0,51	0,342
Satiety Responsiveness	3,24±0,48	2,98±0,42	0,008	3,19±0,51	3,14±0,49	0,528
Slowness in Eating	3,18±0,54	2,86±0,46	0,004	3,22±0,58	3,15±0,55	0,412
Emotional Overeating	2,34±0,62	2,18±0,54	0,142	2,28±0,58	2,24±0,56	0,687
Emotional Undereating	2,92±0,48	2,68±0,44	0,018	2,88±0,52	2,82±0,50	0,456
Desire to Drink	2,64±0,58	2,42±0,52	0,048	2,58±0,54	2,52±0,52	0,524

Description: paired t-test; Data are presented as mean±SD*

Comparison of score changes (delta) between groups is presented in Table 3. The analysis showed that the score changes in the intervention group were significantly greater than those in the control group across all eight CEBQ subscales ($p<0,05$), with the largest between-group effects observed for food fussiness, enjoyment of food, food responsiveness, and slowness in eating (effect size $d>0,8$).

Table 3. Comparison of Changes in CEBQ Scores Between Groups

CEBQ subscales	Δ Intervention	Δ Control	P-value*	Effect Size (d)
Food Fussiness	-0,68±0,42	-0,17±0,38	<0,001	1,27
Enjoyment of Food	0,54±0,38	0,11±0,32	<0,001	1,22
Food Responsiveness	0,34±0,36	0,08±0,28	<0,001	0,81
Satiety Responsiveness	-0,26±0,32	-0,05±0,24	0,001	0,74
Slowness in Eating	-0,32±0,34	-0,07±0,26	<0,001	0,83
Emotional Overeating	-0,16±0,28	-0,04±0,22	0,028	0,48

https://doi.org/10.64146/sw8ztj73

CEBQ subscales	Δ Intervention	Δ Control	P-value*	Effect Size (d)
Emotional Undereating	-0,24±0,30	-0,06±0,24	0,003	0,66
Desire to Drink	-0,22±0,28	-0,06±0,22	0,004	0,64

Description: independent t-test; Δ = difference between posttest and pretest scores; Data are presented as mean±SD*

Analysis of user engagement with the smartphone application *showed a* high level of usage in the intervention group. Based on automatically generated application log data, the average frequency of application access was 4.2 times per week, with an average duration of 15.3 minutes per session. The most frequently accessed features were educational modules (78.4%), followed by demonstration videos (68.2%) and food logging features (54.1%). A total of 88,4% of respondents said they were satisfied with the application, and 91.2% said they were willing to recommend the application to parents.

DISCUSSION

This research shows that smartphone application-based nutrition education is effective in changing the eating behaviour of preschool-aged children in Bengkulu City. These findings are in line with various previous studies that show the potential of digital technology-based interventions to support health behaviour change in family populations with children (Heerman et al., 2024; Talens et al., 2025). The significant decrease in food fussiness scores in the intervention group is a very relevant finding considering the high prevalence of picky eating behaviour in preschool children in Indonesia, which contributes to nutritional problems (Hardini & Wirjatmadi, 2024; Samuel et al., 2023).

The strong intervention effects on the food fussiness (effect size d=1.27) and enjoyment of food (effect size d=1.22) subscales indicate that education that focuses on strategies for introducing new foods and creating positive eating experiences can effectively change children's eating behaviour. These findings are consistent with the concept of repeated exposure, which emphasises the importance of repeated exposure to new foods in increasing acceptance and preference for food in children (Norton et al., 2023). The smartphone application may support the implementation of repeated exposure strategies through daily reminders and practical guidance, as indicated by the high average access frequency of 4.2 times per week recorded in the application log, although the extent to which parents specifically utilized exposure-related features was not directly measured in this study.

An increase in food responsiveness scores, a decrease in satiety responsiveness scores, and slowness in eating in the intervention group showed improvements in children's appetite regulation. This change can be attributed to increased responsive feeding practices by parents as a result of the education provided (Wang et al., 2024). Responsive feeding practices that emphasise sensitivity to children's hunger and satiety cues help children develop the ability to independently regulate food

https://doi.org/10.64146/sw8ztj73

intake, which is reflected in increased interest in food and mealtime efficiency (Carbonneau et al., 2023; Edwards et al., 2024).

The high level of engagement with smartphone applications in this study (average 4,2 accesses per week) indicates that digital platforms can be an effective medium for delivering nutrition education to parents of preschool-aged children. Interactive features such as video demonstrations and food logging increase user engagement and support the application of knowledge in daily practice (Cox et al., 2023; Milne-Ives et al., 2024). The Health Belief Model-based approach applied in application content design plays a role in increasing perceptions of the vulnerability and severity of children's nutritional problems, as well as the benefits of changing feeding practices (Rachmah et al., 2023; Riazi et al., 2024).

The advantages of smartphone application-based interventions compared to conventional education lie in the flexibility of access, personalisation of content, and continuity of support provided (Hayek et al., 2025; Porri et al., 2024). Parents can access educational materials at any time as needed, receive reminders tailored to individual conditions, and get ongoing support through the discussion forum feature. This overcomes common obstacles in conventional education, such as limited time to attend counselling sessions and a lack of follow-up after the program ends (Pereira et al., 2021; Murimi et al., 2018).

This study has several limitations that need to be considered in interpreting the results. First, the quasi-experimental design with allocation based on health centre area does not allow full randomisation, so even though baseline characteristics are comparable, the potential for selection bias cannot be completely eliminated. Second, the measurement of children's eating behaviour relies on parental report via the CEBQ questionnaire, which may be influenced by reporting bias and social desirability (Brown et al., 2022; Chen et al., 2024). Third, the relatively short follow-up duration (8 weeks) is not yet sufficient to evaluate the sustainability of the intervention effect in the long term. Future research is recommended to use a randomised controlled trial design with longer follow-up and integrate objective measurements of children's eating behaviour to validate the findings.

CONCLUSION

This study provides empirical evidence that smartphone application-based nutrition education can improve children's eating behaviour by empowering parental feeding practices in Bengkulu City. Significant improvements were observed in most CEBQ subscales, most notably food fussiness and enjoyment of food, with large effect sizes ($d > 0.8$), whereas emotional overeating did not change significantly, indicating that the intervention's effect was not uniform across all eating behaviour domains.

The high level of user involvement and respondent satisfaction with the application indicates good acceptance of digital technology-based educational approaches in the context of urban society

https://doi.org/10.64146/sw8ztj73

in Indonesia. These findings suggest that a mobile application-based nutrition education intervention can improve parental feeding practices and children's eating behaviour, although further research is needed to determine whether such improvements translate into measurable changes in nutritional status and to assess the feasibility of broader implementation. Future studies should investigate whether technology accessibility and digital literacy among target communities moderate the effectiveness of mobile application-based nutrition education, as these factors were not measured in the present study yet may influence the scalability of such interventions at the primary health care level.

Further research is needed to evaluate the long-term effectiveness of this intervention on parental feeding practices and children's eating behaviour, to assess whether the observed improvements are sustained beyond the intervention period, and to examine the scalability of implementation across diverse population settings with varying sociodemographic characteristics.

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