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# EFFECTIVENESS OF A SMARTPHONE – BASED EDUCATION INTERVENTION TO IMPROVE BREASTFEEDING AND NEONATAL NUTRITIONAL STATUS: A RANDOMISED CONTROLLED TRIAL

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## ABSTRACT

Exclusive breastfeeding is critically important during the first six months of an infant's life, offering numerous health benefits for both mothers and babies. A randomized controlled study was conducted involving a sample of 674 new mothers (224 in the control group and 450 in the intervention group) new mothers with their child aged under one month for a period of six months to evaluate the effectiveness of a breastfeeding smartphone-based educational intervention at Kenyatta National Hospital in Nairobi, Kenya. Participants were randomly assigned to the intervention group which received (mobile app-based education + routine care) and the control group (routine care). A total of 412 mother-infant dyads completed the study, representing 61.1% of the recruited participants in the study, with 206 in the intervention group and 206 in the control group. After six months, the following findings were observed; the intervention group showed a significant ($p<0.01$) improvement in breastfeeding knowledge, with a mean (±S.D.) score of 70.33% (±7.68), compared to 58.52% (±16.5) in the control group, resulting in a difference-in-difference of means (DID means = 3.53%, $p<0.01$). Attitudes toward breastfeeding improved significantly ($p<0.01$) in the intervention group, with a mean score of 73.58% (±6.79), compared to 47.75% (±9.96) in the control group, with a difference-in-difference of means (DID means = 1.60%, $p<0.01$). Practices significantly ($p<0.01$) improved, with the intervention group scoring 73.95% (± 2.66), while the control group scored 53.89% (±9.85), resulting in a difference-in-difference of means (DID means = 9.12%, $p<0.01$). At baseline, the mean (±S.D.) weight of infants was 2.82 kg (±0.87) and 2.98 kg (±0.62) in the control and intervention group respectively. Both groups experienced an increase in weight, with the control group averaging 7.36 kg (±0.91) and the intervention group averaging 7.82 kg (±0.94). Both groups had increased in height, with the control group measuring the mean (±S.D.) 67.42 cm (±2.43) and the intervention group measuring 67.95 cm (±2.87). There was significant ($p<0.01$) weight gain in intervention group infants (DID means = 0.28 kg, $p<0.01$) and length gain (DID means = 1.31 cm, $p<0.01$). Finally, the intervention group underweight reduced to 4.9%, stunting to 1.9%, and wasting to 4.4% resulting in statistical significant ($p<0.01$) reduction in malnutrition prevalence. The mobile app-based intervention significantly improved breastfeeding knowledge, attitudes, practices, and infant health, reducing malnutrition prevalence effectively. Hospital-based nutritionists should consider using mobile apps to monitor lactating mothers' exclusive breastfeeding adherence, while policymakers support their integration in post-natal care.

**Key words:** Smartphone intervention, breastfeeding knowledge, attitude, practices, Infant nutritional status, Kenya

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## INTRODUCTION

Globally, more than 20 million babies are born underweight each year [1], particularly in low- and middle-income countries; this problem is a global concern. The first 28 days of life are referred to as the neonatal phase, and they are a crucial time for assuring the best possible growth and development [2]. For the establishment of healthy metabolic pathways, immunological function, and cognitive development, adequate diet is crucial throughout this period [3]. It can be difficult to achieve and maintain an appropriate nutritional status in newborns, especially in environments with little resources where assistance and healthcare services may be hard to come by according to Mayner *et al.* [4]. The risk of newborn death is four times higher for babies born weighing less than 2.5 kg than for those delivered weighing more [5].

For newborns weighing less than 2 kg, this risk increases to 18 times higher. Furthermore, stunting and malnutrition during infancy and adulthood increases risks for low birth weight babies [6]. The global use of mobile phones has changed the way healthcare is delivered in recent years, opening up new opportunities to increase patient access, effectiveness and efficiency [7]. In the context of neonatal nutrition, mobile apps have tremendous promise for enhancing the control of nutritional status from birth through the early infancy period [8].

Breastfeeding is the best feeding method for infants, offering numerous health benefits and fostering a strong mother-child bond. However, many mothers struggle with establishing and maintaining successful breastfeeding practices [9]. Research highlights that early postpartum support significantly impacts breastfeeding success, however, many new mothers lack timely and accurate information and support [10]. Mobile phone applications have emerged as effective tools, providing personalized support, resources, tracking functionalities, and real-time assistance [11]. The research addresses the lactation support gap by creating a smartphone application that offers mothers useful tools and evidence-based information, helping them navigate breastfeeding challenges such as latching issues and milk supply concerns [12, 13].

The World Health Organization (WHO) recommends exclusive breastfeeding (EBF) for the first six months of life, and then continuing breastfeeding for up to 24 months or longer, supplemented with safe, nutrient-dense meals [14]. Despite these recommendations, only 73% of infants receive any breast milk by the time they become one year old, and less than 40% of babies globally receive breast milk exclusively for the whole six months. Enhancing breastfeeding outcomes and promoting maternal breastfeeding knowledge, attitude, behaviours, and infant nutritional status are the objectives of utilizing mobile technology [15]. The mobile app aimed to facilitate breastfeeding and support growth monitoring practices, and

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improve caregiver education [16, 17]. In Kenya, the Demographic and Health Surveys reported that the prevalence of exclusive breastfeeding among infants under six months was 60% in 2022 and 11% of child undernutrition in Nairobi City, Kenya [18], hence, this study sought to develop a breastfeeding application that significantly improved breastfeeding knowledge, attitudes, practices and infant nutritional status.

## MATERIALS AND METHODS

### Study Setting

This study was conducted at Kenyatta National Hospital (KNH) in Nairobi County, Kenya. Nairobi City is located geographically, at 1°17'S 36° 49'E, and enjoys a subtropical highland climate and occupies a total area of 696 square Kilometers. The KNH stands as Nairobi, Kenya's largest health facility under the Ministry of Health. It also serves as the largest teaching and referral public hospital in East and Central Africa. With an impressive inpatient capacity of 2,000 beds, it plays a pivotal role in healthcare provision and medical research environment.

### Study Design, Population and Sampling

This study employed a parallel, efficacy randomized control trial (RCT) design to evaluate the effectiveness of a mobile phone application breastfeeding education intervention compared to standard postnatal care. The sample size for the independent cohort was calculated using the formula by Kasiulevičius [19] based on infant underweight prevalence of 10% as an outcome variable according to the Kenya Demographic and Health Survey 2022 (KDHS, 2022).

$$n = \frac{\left[Z\alpha\sqrt{(1+1/m)\bar{p}(1-\bar{p})} + Z_{\beta}\sqrt{P_o(1-p_o)m + p_1(1-p_1)}\right]^2}{(p_o - p_1)^2}$$

Where $\bar{p} = \frac{p^1 + m\,p_o}{m+1}$

$P_0$ was the probability of underweight infants in the control group – 0.10.
$P_1$ was the probability of underweight infants in the intervention group – 0.07.
$P_0$ was based on the Kenya Demographic Health Survey 2022 burden of malnutrition in the Nairobi County region while $P_1$ was an estimated reduction in underweight with the intervention.
If α (alpha) = 0.05 then $z_\alpha$ = 1.96.
If β (beta) = 0.80, then $z_\beta$ = 0.845.
*m* was the number of control subjects per experimental subject = 2.
p− = 0.0987
*N* = 674 with the inclusion of 20% loss to follow-up of mother-baby dyads. A sample size of 674 (224 in the control group and 450 in the intervention group) was

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estimated to detect a 4.3% reduction in the underweight infants at 80% power and 5% level of significance.

The inclusion criteria were breastfeeding mothers attending the postnatal clinic at Kenyatta National Hospital, residing in Nairobi County for at least six months before data collection and owning a smartphone with proficiency in mobile applications. Exclusion criteria included mother - child dyads unable to respond due to health issues. Fifteen individuals from the postnatal clinic at KNH voluntarily participated in the pretest. Adjustments improved question clarity and reduced redundancies. Pretest participants were excluded from the study sample. The test-retest method ensured reliability, and Cronbach's alpha (α) greater than 0.7 indicated acceptable reliability. The questionnaire's validity was also rigorously examined.

## Data Collection

### Breastfeeding Mobile Phone Application Development

This was an android based application which was implemented using Native Java, Extensible Markup Language (XML) and SQLite. The application was primarily used by the breastfeeding mothers to learn more about breastfeeding and then at the end an assessment was carried out to assess mothers' knowledge, practices, attitude and infant nutritional status in a randomized control study. The app provided comprehensive information on breastfeeding techniques, benefits, and troubleshooting. This content was designed to be accessible and engaging, with interactive elements to help mothers understand and apply the information effectively.

### Randomization and Blinding Enrollment

After baseline assessment, eligible mothers were allocated to the intervention or control group using a Web-based randomization tool [20] with a ratio 1:2 to minimize the anticipated level of drop out in the intervention group. Data collectors and care providers were blinded to group assignment and just investigated the inclusion criteria in the hospital. The researcher implementing the randomization procedure was blind to the participants and had not cooperated in the recruitment process. After determining intervention and control group members, telephone calls were made to the mothers in the intervention arm and they were asked to install the app-based educational program to their phones over the Internet and social media. Alternatively, they could visit the clinic and have the app installed on their phones. A visit was made in the intervention group in a different room to avoid the control group's possible access to the mobile app. Given the specific characteristics of the intervention, it was not feasible to blind all participants or practitioners involved in the study. However, significant measures were implemented to ensure that any potential biases were effectively mitigated. In addition to self-reported data, the study

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could collect information from healthcare providers, such as pediatricians or lactation consultants, who can verify the duration and exclusivity of breastfeeding. By comparing self-reported data with medical records or professional observations, researchers can cross-validate the information.

**Study Intervention**

In the study, both intervention and control groups followed a structured clinic visit process as expected. The intervention group underwent triage, where nurses assessed vital signs such as blood pressure, heart rate, weight and height. They then met with the principal researcher for further intervention steps. A breastfeeding educational app was installed on their phones, designed to address breastfeeding challenges over a six-month period. Two independent nurses followed up with the mothers twice weekly, encouraging app usage and discussing breastfeeding issues. They guided mothers to relevant app sections based on their specific problems. The app featured educational modules, personalized tracking, and community support to enhance breastfeeding knowledge, attitude, practices and infant nutrition. The breastfeeding knowledge focused on mother's understanding of topics such as the nutritional benefits of breast milk, the importance of exclusive breastfeeding during the first six months, the advantages of breastfeeding for the child's immunity, and common breastfeeding challenges like engorgement or latch issues. The breastfeeding attitude in this section equipped the mother's perception of breastfeeding as a natural, bonding activity, as well as her beliefs about its importance for both the child's health and her own well-being. Breastfeeding practices also equipped mothers about exclusive breastfeeding, when to introduce complementary foods, and whether she encounters any breastfeeding challenges, such as sore nipples, low milk supply, or difficulties with latch.

Patient confidentiality was maintained, and contact information was collected for SMS reminders about upcoming clinic visits to ensure ongoing engagement. In contrast, the control group received standard postnatal care at Kenyatta National Hospital. They also underwent vital sign assessments in the triage area and saw a healthcare provider, but their history and examination findings were recorded in a booklet attached to their patient file. There was no use of the mobile application for the control group.

**Outcomes**

The primary outcome was the change in mothers' breastfeeding knowledge, attitude, practices and infant nutritional status from baseline to 6 months. Secondary outcomes included changes in infant growth indicators such as length and weight measured using a standardized protocol recommended by World Health Organization (WHO).

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### Mothers' Breastfeeding Knowledge, Attitude and Practices Assessment

To evaluate the impact of a mobile phone application intervention on the breastfeeding knowledge, attitudes, and practices of mothers in both intervention and control groups. Questions in this section assessed a mother's understanding of topics such as the nutritional benefits of breast milk, the importance of exclusive breastfeeding during the first six months, the advantages of breastfeeding for the child's immunity, and common breastfeeding challenges like engorgement or latch issues, while the attitude questions assessed the mother's perception of breastfeeding as a natural, bonding activity, as well as her beliefs about its importance for both the child's health and her own well-being. Then breastfeeding practices sought to determine how frequently the mother breastfeeds, whether she practices exclusive breastfeeding, when she introduces complementary foods, and whether she encounters any breastfeeding challenges, such as sore nipples, low milk supply, or difficulties with latch using a structured questionnaire after interaction with the breastfeeding app. By comparing baseline and end-line data, the study aimed to assess the effectiveness of the intervention.

### Infant Anthropometric Measurements

Infant anthropometric measurements were taken to assess growth and nutritional status. Standard procedures were followed for measuring weight and length. A calibrated digital scale was used for weight and infantometer for length. Measurements were taken in accordance with WHO guidelines, using WHO growth standards as reference values to interpret results. Trained personnel conducted all measurements to ensure accuracy and consistency [21]. These analyses compared the growth outcomes of infants in terms of weight, height, and Z-scores in the intervention and control groups at baseline (3 weeks old) and at the 6-month follow-up.

### Consolidated Standards of Reporting Trials (CONSORT)

The Consolidated Standards of Reporting Trials (CONSORT) flow diagram, as depicted in Figure 1, offered a clear visual representation of participant progression through the phases of a clinical trial [22]. This approach ensured a systematic and transparent method for reporting trials, enhancing the reliability and reproducibility of research findings. In the diagram provided, the trial begins with the enrollment phase, where 674 participants were assessed for eligibility. From this initial pool, 22 participants were excluded for various reasons: 8 were admitted in intensive care unit, 4 declined participation, 3 did not have a smartphone, and 7 were recruited twice.

The remaining 652 participants were randomized into two groups: 217 were allocated to the control group and 435 to the intervention group. This allocation phase was crucial for ensuring that the study groups are comparable, which is

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essential for the validity of the trial's outcomes. Following allocation, the follow-up phase tracked participants' adherence to the study protocol. In the control group, 11 participants were lost to follow-up, and 4 did not attend the initial visit. In the intervention group, a significantly higher number of participants were lost to follow-up (229), with reasons including not attending the initial visit (87), changing their mind (79), and being unable to be contacted (63). Finally, 206 mother-infant dyads completed the study in both the control and intervention groups. This number of completed cases across both groups was used for comparing the outcomes accurately.

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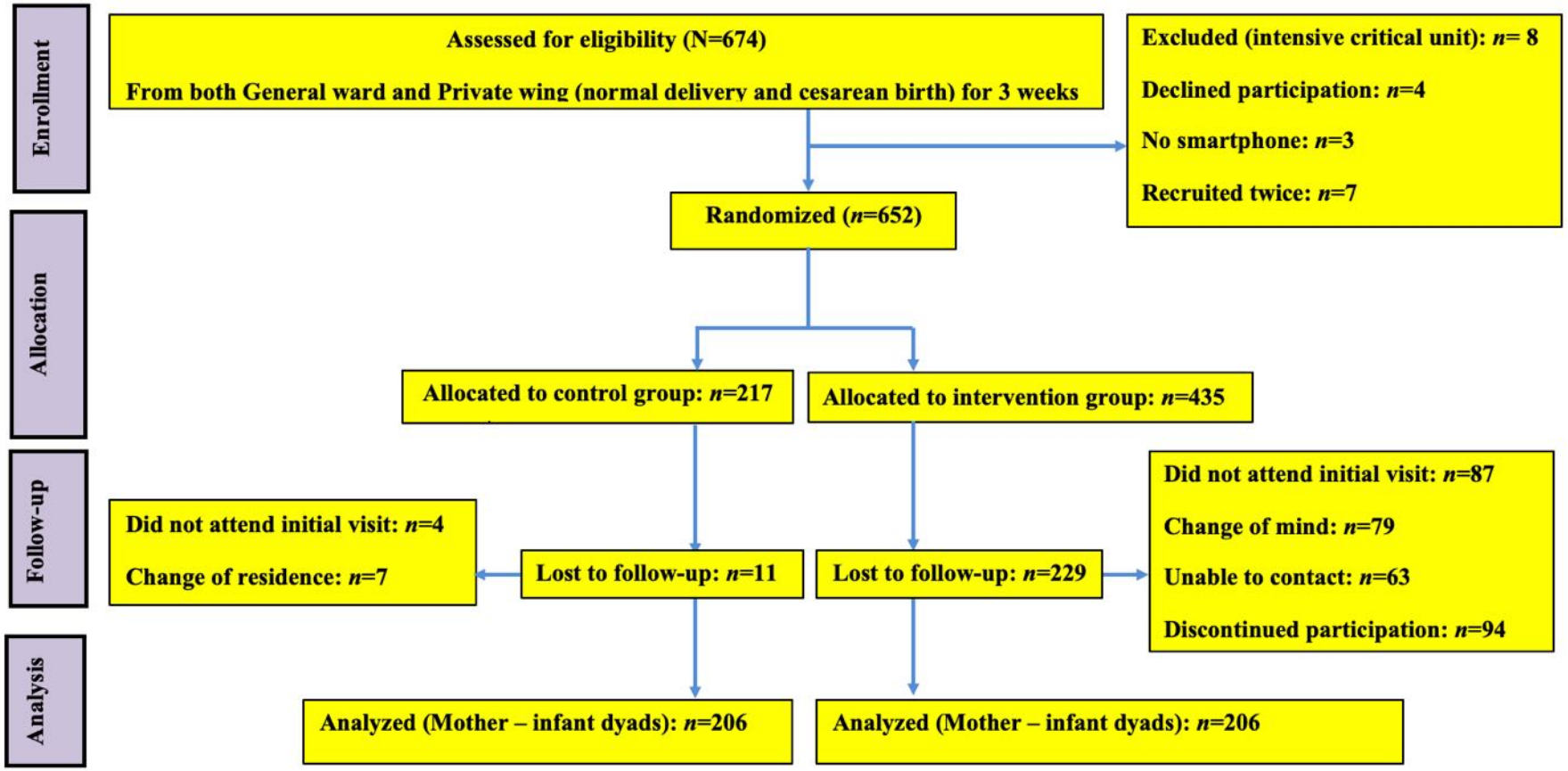


**Figure 1: Consolidated Standard of Reporting Trials flow diagram [22]**

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### Statistical Data Analysis

Data entry templates were developed in Statistical Package for Social Sciences (SPSS) v.24. The same software was used for statistical analysis. The data was first examined for any missing values. Next, the quantitative data was explored to identify any outliers, which were defined as values significantly deviating from the mean by being either excessively high or low. The Emergency Nutrition Assessment (ENA) software was used to generate anthropometric scores using both the WHO growth standards and automated nutrition indicators.

### Ethical Approval

The study involved human participants and was approved by (KNH/UON) Ethics Research Committee, under the reference number P236/03/2022. Additionally, approval was obtained from the National Commission for Science, Technology, and Innovation (NACOSTI), with the reference number NACOSTI/P/22/22489. All the study participants gave informed voluntary written consent. Information provided by the participants was held confidential to ensure patients' privacy, dignity and their fundamental rights under the Data Protection Act, No 24 of 2019.

## RESULTS AND DISCUSSION

### Socio – demographic Characteristics

A higher proportion of young mothers, those under 20 years of age, was found in the intervention group (36.4%, *n* = 75) compared to the control group (32.4%, *n* = 66). Additionally, more mothers in the intervention group (75.2%, n = 155) resided in non-slum areas than in the control group (61.7%, *n* = 127). The majority of participants in both groups were Kenyan, with a slightly higher representation in the intervention group (83.5%, *n* = 172). The intervention group also showed a greater proportion of married (53.9%, *n* = 111) and single mothers (31.4%, *n* = 64), whereas the control group had a higher percentage of divorced (14.6%, *n* = 30) and widowed mothers (7.8%, *n* = 16) (Table 1).

Regarding education, both groups had a high proportion of mothers with formal schooling, though the control group had a slightly higher percentage (71.8%, *n* = 158). Employment patterns differed as well: the intervention group included more salaried employees (38.8%, *n* = 80), while the control group had a larger proportion of self-employed mothers (49.5%, *n* = 102). Religious affiliation varied between the groups, with the intervention group having a higher percentage of Catholics (34.0%, *n* = 70) and a lower percentage of Muslims (6.3%, *n* = 13) compared to the control group. Finally, Safaricom was the predominant service provider for both groups, with a slightly higher share in the intervention group (75.2%, *n* = 155). (Table 1) Younger mothers, those with lower levels of formal education, and working mothers face unique barriers that could benefit from targeted interventions. For instance, younger

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mothers and those with non-formal education might require additional educational resources to better understand and implement postnatal care practices, aligning with recent findings suggesting that custom-designed educational and support resources can significantly enhance engagement and outcomes [23]. Additionally, Studies have consistently shown that tailoring interventions to the specific needs of different demographic groups leads to more effective and impact care [24].

**Breastfeeding Knowledge, Attitude and Practices**

For breastfeeding knowledge (Table 2), the intervention group showed a significant improvement, with a mean (±S.D.) score of 70.33% (± 7.68) at the end of the study, compared to 58.52% (± 16.5) in the control group, resulting in a difference-in-difference of means (DID means = 3.53%, $p<0.01$). Similarly, attitudes toward breastfeeding improved significantly in the intervention group, reaching a mean score of 73.58% (± 6.79), compared to 47.75% (± 9.96) in the control group, with a difference-in-difference of means (DID means = 1.60%, $p<0.01$). Practices also saw notable improvements, with the intervention group scoring 73.95% (± 2.66) at the end of the study, while the control group scored 53.89% (± 9.85), resulting in a difference-in-difference of means (DID means = 9.12%, $p<0.01$).

The significant increase in knowledge indicates that mobile-based interventions are powerful tools for educating mothers about breastfeeding, potentially improving health outcomes for both mothers and infants. This aligns with Zhang's findings on the effectiveness of online breastfeeding education for mothers of preterm infants [25]. Mobile apps enhance mothers' knowledge of breastfeeding techniques, benefits, and challenges by providing detailed information on proper latch techniques, managing common issues, and the nutritional benefits of breastfeeding [26]. Studies have consistently shown that effective breastfeeding education significantly improves mothers' understanding, reducing health complications for both mothers and infants [26]. Improved knowledge contributes to better health outcomes and can decrease healthcare costs associated with breastfeeding-related issues. The economic benefits highlight the value of investing in mobile-based solutions as a cost-effective public health strategy. For example, a study on a breastfeeding support app revealed that mothers who used the app were more likely to initiate and continue breastfeeding compared to non-users [27]. Research on a specific breastfeeding support app found that users were more likely to practice exclusive breastfeeding, as recommended by the World Health Organization (WHO), compared to non-users [28].

Apps provide actionable tips that can be easily integrated into daily routines, such as feeding schedules, milk expression methods, and dietary recommendations [29]. This straightforward advice enables mothers to make informed decisions and adjust their practices. The accessibility of mobile apps ensures that mothers can access

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guidance whenever needed, without waiting for scheduled appointments. This immediate access to information is particularly beneficial during the early postpartum period when timely support is crucial [30]. Research has shown that mothers who used a breastfeeding support app reported higher rates of breastfeeding initiation and continuation compared to non-users [25].

**Comparison of Mean Weight, Length and Z - score Indices of Infants after Intervention**

At baseline, the average weight of infants in the control group was 2.82 kg, while the intervention group had a slightly higher average weight of 2.98 kg. By the 6-month follow-up, both groups saw a significant weight increase, with the control group averaging 7.36 kg and the intervention group averaging 7.82 kg. The intervention group showed a greater weight gain, with a statistically significant difference of 0.28 kg ($p<0.001$).

In terms of length, the control group infants were slightly longer at baseline (42.32 cm) compared to the intervention group (41.54 cm). After six months, the control group averaged 67.42 cm, while the intervention group averaged 67.95 cm, with a statistically significant height difference of 1.31 cm ($p<0.01$). The Weight-for-Age Z-score (WAZ) improved significantly in the intervention group, increasing by 1.1 points from -1.97 to -0.87, while the control group remained stable at -1.97. The Height-for-Age Z-score (HAZ) in the intervention group improved by 0.48 points from -0.37 to -0.85, whereas the control group declined significantly by 1.05 points from -0.69 to -1.74. The Weight-for-Height Z-score (WHZ) showed no significant difference between the groups at follow-up.

These findings highlight the positive impact of the intervention on infant growth, particularly in weight gain and height increase, as evidenced by the significant differences in mean values and p-values (all $p<0.01$) between the intervention and control groups. Abadi *et al*. [31] highlight that mobile apps designed for nutritional education and breastfeeding support can positively impact growth outcomes by improving adherence to recommended feeding practices. Similarly, Knop *et al.* [32] found that mothers using a breastfeeding app demonstrated better adherence to feeding guidelines, which was associated with healthier weight and height gain in their infants compared to those who did not use the app. A study by Acar *et al*. [33] reported that mothers who utilized an app to track their infant's growth patterns experienced more consistent weight and height gains in their children. This underscores the value of regular monitoring; as the app's tracking capabilities enable timely adjustments to feeding practices and more effective management of infant growth. Previous research has similarly demonstrated that mobile applications providing breastfeeding education and support can lead to improved feeding practices and better infant growth outcomes [32, 34].

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### Infant Nutritional Status Prevalence at Baseline and End-line

There was a significant decline (Table 4) in the prevalence of underweight infants in the intervention group, from 12.1% at baseline to 4.9% at end-line, whereas the control group saw an increase in underweight infants, from 9.7% to 13.6% (OR = 0.39, p = 0.01). This suggests that the intervention had a positive effect, reducing the likelihood of underweight in the intervention group compared to the control group. Additionally, the prevalence of wasted infants in the intervention group dropped significantly, from 14.6% at baseline to 4.4% at end-line, while the control group's wasting prevalence increased from 9.2% to 12.1% (OR = 0.56, p = 0.01). This implies that the intervention significantly reduced the prevalence of wasting. While there was a decrease in the prevalence of stunted infants in the intervention group from 2.4% to 1.9%, compared to an increase in the control group from 2.9% to 4.4%, this difference was not statistically significant (OR = 0.67, p = 0.33). The reduction in the prevalence of underweight, stunting and wasting in infants suggests that the mobile phone application had a positive impact on the breastfeeding practices and overall nutritional support provided to the infants [31, 35].

A study showed that improved nutritional practices facilitated by a mobile phone application reduced underweight prevalence, aligning with Vila-Candel *et al*. [35]. The intervention significantly reduced wasting rates, demonstrating its efficacy in improving infant nutrition through enhanced breastfeeding practices. The statistically significant difference in wasting rates between the intervention and control groups underscores the potential of mobile applications as effective health education platforms [36, 37].

## CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The intervention significantly improved breastfeeding knowledge, attitudes and practices among mothers, leading to better infant growth indices and reduced underweight and wasting prevalence. To support younger mothers, those with non-formal education, and working mothers, targeted educational resources and flexible clinic hours are essential. Future studies should assess similar interventions in various geographical and healthcare settings to determine the application's effectiveness across different cultural and socioeconomic contexts.

Long-term effects on breastfeeding practices and infant nutrition should also be explored, with extended follow-up periods to evaluate sustained benefits. The current standard care may be insufficient for optimal infant nutritional status, as seen in the control group's needs, therefore supplementary support, such as additional nutrition counseling, educational resources, or community support groups, is recommended. Engaging policymakers to improve existing nutrition support services

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are essential. These strategies can provide mothers with the guidance and resources needed to support infant health, even beyond mobile app interventions.

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### Competing interest

The authors declare no competing interest regarding the publication of this manuscript.

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**Table 1: Mothers' Socio-demographic Statistics in the Intervention and Control Groups**

| Variables | Control Group *n* = 206 | | Intervention Group *n* = 206 | |
|---|---|---|---|---|
| | % | (*n*) | % | (*n*) |
| **Age** | | | | |
| <20 years | 32 | (66) | 36.4 | (75) |
| >20 years | 68 | (140) | 63.6 | (131) |
| **Area of Residence** | | | | |
| Non-slum areas | 61.7 | (127) | 75.2 | (155) |
| Slum areas | 38.3 | (79) | 24.8 | (51) |
| **Nationality** | | | | |
| Kenyan | 76.2 | (157) | 83.5 | (172) |
| Non-Kenyan | 23.8 | (49) | 16.5 | (34) |
| **Marital Status** | | | | |
| Married | 49 | (101) | 53.9 | (111) |
| Single | 28.6 | (59) | 31.1 | (64) |
| Divorced | 14.6 | (30) | 10.7 | (22) |
| Widowed | 7.8 | (16) | 4.4 | (9) |
| **Education status** | | | | |
| Non-formal education | 25.7 | (53) | 28.2 | (58) |
| Formal education | 74.3 | (153) | 71.8 | (158) |
| **Occupational status** | | | | |
| Salaried employee | 25.2 | (52) | 38.8 | (80) |
| Self-employed | 49.5 | (102) | 38.3 | (79) |
| Unemployed | 23.8 | (49) | 22.8 | (47) |
| **Religion status** | | | | |
| Catholic | 21.8 | (48) | 34.0 | (70) |
| Protestant | 49 | (101) | 48.1 | (99) |
| Muslim | 18.0 | (37) | 6.3 | (13) |
| SDA | 11.2 | (23) | 11.7 | (24) |
| **Telephone service provider** | | | | |
| Safaricom | 69.9 | (144) | 75.2 | (155) |
| Airtel | 23.3 | (50) | 18.9 | (39) |
| Telkom | 5.8 | (12) | 5.8 | (12) |

n: Number of mothers in each group

% (n): Percentage of mothers and the corresponding number of mothers in each demographic category

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**Table 2: Frequency Distribution and Analyses of Breastfeeding Knowledge, Attitude, and Practices of Mothers before and after Mobile Phone Application Breastfeeding Education Intervention**

| Control Group n = 206 | | Intervention Group n = 206 | Differences | | Differences in differences of means | P- value |
|---|---|---|---|---|---|---|
| **Variable** | **Mean** ± SD | **Mean** ± SD | **Intervention** | **Control** | | |
| **Knowledge** | | | | | | |
| Baseline | 60.32 ± 17.49 | 65.0 ± 16.59 | | | | |
| Endline | 58.52 ± 16.5 | 70.33 ± 7.68 | 5.33 | -1.8 | 3.53 | 0.01 |
| **Attitude** | | | | | | |
| Baseline | 49.83 ± 9.97 | 69.9 ± 9.87 | | | | |
| Endline | 47.75 ± 9.96 | 73.58 ± 6.79 | 3.68 | - 2.08 | 1.6 | 0.01 |
| **Practices** | | | | | | |
| Baseline | 56.92 ± 10.25 | 61.8 ± 10.27 | | | | |
| Endline | 53.89 ± 9.85 | 73.95 ± 2.66 | 12.15 | -3.03 | 9.12 | 0.01 |

**n:** Number of mothers in each group
**Mean ± SD:** Mean value and standard deviation for each variable
**Differences:** The difference in mean values for each variable from baseline to end-line within the intervention and control groups.
**Differences in differences of means:** The difference in the changes of mean values between the intervention and control groups from baseline to endline
**P-value:** The p-value associated with the test of the differences in differences. A p-value < 0.05 indicates statistical significance

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**Table 3: Comparison of Mean Weight and Length of Infants in Intervention and Control Groups at Baseline and EndLine**

| Variables | *Baseline (3 weeks old infants)* | | *6 Months follow-up* | | Mean Differences | | Differences in difference of the means | *P - value* |
|---|---|---|---|---|---|---|---|---|
| | Control | Intervention | Intervention | *Control* | | | | |
| | | | | | Intervention | Control | | |
| **Weight (kg)** (Mean ± S.D.) | 2.82 ± 0.87 | 2.98 ± 0.62 | 7.82 ± 0.94 | 7.36 ± 0.91 | 4.82 | 4.54 | 0.28 | 0.01 |
| **Height (cm)** (Mean ± S.D.) | 42.32± 1.99 | 41.54 ± 1.53 | 67.95 ± 2.87 | 67.42 ± 2.43 | 26.41 | 25.1 | 1.31 | 0.01 |
| **WAZ** (Mean ± S.D.) | -1.98±0.67 | -1.97±0.47 | -0.87±0.59 | -1.97±0.83 | 1.1 | -0.01 | 1.09 | 0.01 |
| **WHZ** (Mean ± S.D.) | -0.95±0.86 | -0.99±0.88 | -0.96±0.97 | -1.59±0.85 | -0.03 | -0.64 | 0.06 | 0.01 |
| **HAZ** (Mean ± S.D.) | -0.69±0.79 | -0.37±0.98 | -0.85±0.71 | -1.74±0.76 | -0.48 | -1.05 | 0.57 | 0.01 |

**Mean ± S.D.:** Mean value and standard deviation for each variable
**Mean Differences:** The difference in mean values for each variable from baseline to 6 months follow-up within the intervention and control groups
**Differences in difference of the means:** The difference in the changes of mean values between the intervention and control groups from baseline to 6 months follow-up
**P-value:** The p-value associated with the test of the differences in difference. A p-value < 0.05 indicates statistical significance.
**WAZ:** Weight-for-age Z-score
**WHZ:** Weight-for-height Z-score
**HAZ:** Height-for-age Z-score

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**Table 4: Prevalence of Underweight, Stunting, and Wasting in Infants at Baseline and End-Line in Intervention and Control Groups within a Mothers' Mobile Phone Application Breastfeeding Education Intervention**

| Variable | Intervention n = 206, % (n) | Control n = 206, % (n) | Odds Ratio | *P – value* | Difference in difference (percentages) | *P – value* |
|---|---|---|---|---|---|---|
| **Underweight** | | | | | | |
| Baseline | 12.1 (25) | 9.7 (20) | 1.71 | 0.23 | (4.9-12.1) = -7.2<br>(13.6-9.7) = 3.9<br>(-7.2-3.9) **- 11.1** | <0.01 |
| End-line | 4.9 (10) | 13.6 (28) | 0.39 | **0.01** | | |
| **Stunting** | | | | | | |
| Baseline | 2.4 (5) | 2.9 (6) | 2.41 | 0.42 | (1.9-2.4) = -0.5<br>(4.4-2.9) = 1.5<br>(-0.5-1.5) = **– 2** | <0.01 |
| End-line | 1.9 (4) | 4.4 (9) | 0.67 | 0.33 | | |
| **Wasting** | | | | | | |
| Baseline | 14.6 (30) | 9.2 (19) | 1.59 | 0.53 | (4.4-14.6) = -10.2<br>(12.1-9.2) = 2.9<br>(-10.2-2.9) **- 13.1** | <0.01 |
| End-line | 4.4 (9) | 12.1 (25) | 0.56 | **0.01** | | |

**(n):** Number of infants in each group
**Odds Ratio:** The odds ratio comparing the intervention group to the control group for each variable
**P-value:** The p-value associated with the test of the odds ratio
**Difference in difference (percentages):** The calculated difference in the proportion of each outcome (underweight, stunting, and wasting) between baseline and end-line for both the intervention and control groups. This value is computed as the change in the intervention group minus the change in the control group
The values in parentheses represent the number of infants (n) exhibiting each condition
P-values < 0.05 are considered statistically significant

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