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Use of a mHealth Approach for the Training of Health-care Providers on Nutrition Counseling in a Malnutrition Clinic

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Abstract

BACKGROUND: The use of mobile phones as job aides is one of the most innovative mHealth applications for community health professionals. However, few studies indicated an influence of mHealth on clinical outcomes in low-income countries.

AIM: Therefore, the researchers conducted the present study to assess the impact of providing updated training packages using mobile technology to service providers on the knowledge of children's caregivers and the quality of performance of service providers.

METHODS: A quasi-experimental pre-posttest of separate samples was conducted in a malnutrition clinic. The total sample size was 400 cases (200 caregivers as a pre-intervention group [pre-IG] and 200 caregivers as a post-intervention group [post-IG]), with inclusion criteria of having their children 6–24 months old. The study interventions composed of five activities: Orientation sessions on nutrition counseling for physicians and nurses, a software (e-health) program loaded in e-tablet to be used during nutrition counseling by physicians, a booklet on proper infant and child feeding, conducting on-the-job training for the nurses, and establishing counseling cycle in the clinic.

RESULTS: After the study intervention, the total knowledge score for all items of children's nutrition increased from 39% among pre-IG to be 80% among post-IG. The majority (more than 90%) of post-IG received four services packages.

CONCLUSION: Participation of service providers in five articulating interventions for nutrition counseling contributes to improving the knowledge of children's caregivers. Practice Implications: Using mobile technology improved the quality of nutrition care services delivered in the malnutrition clinic.

Introduction

Child malnutrition constitutes one of the major global public health problems. Despite considerable improvements in key nutrition measures, development is insufficient to meet the 2025 global nutrition goals [1]. Egypt has achieved minimal progress toward exclusive breastfeeding and stunting goals. However, Egypt has made little progress toward eliminating childhood wasting [2].

Child malnutrition is multifactorial; it necessitates coordinated efforts from policy, the health system, and health personnel [2]. One of the most effective strategies for improving children's nutritional status is capitalizing on existing health-care providers' resources to provide caregivers with correct, adequate, and frequent nutrition advice and counseling. However, medical education has lacked adequate and updated nutrition training that responds to the deteriorated nutritional status of children [3], [4], [5].

In-service nutrition training has improved health workers' nutrition knowledge, nutrition counseling skills, and care of malnourished children. The impact of health workers' counseling on feeding behaviors, such as food diversity, feeding frequency, calorie intake, supplementary feeding, and children's nutritional status, has been widely recognized [6], [7]. However, creative approaches such as integrating mobile health technology into the methodology of in-service training for health staff in Egypt are required to be more effective. The use of mobile phones as job aides is one of the most innovative mHealth applications for community health professionals [5], [6]. However, few studies indicated an influence of mHealth on clinical outcomes in low-income countries. Therefore, the researchers conducted the present study to assess the impact of providing an updated training package using mobile technology to service providers on the knowledge of children's caregivers and the quality of performance of service providers.

Methods

Study setting and design

The study was an operations research intervention study using a quasi-experimental separate

sample pretest-posttest design conducted in a malnutrition clinic after getting ethical approval from Cairo University.

Sample size and technique

All physicians and nurses who provided nutrition rehabilitation services to malnourished children at a malnutrition clinic and worked in the clinic at the study time were included in the study. The study included a purposive sample of caregivers and their children attending the malnutrition clinic for 3 months. The sample size was estimated at 400 cases: 200 caregivers and their children for the pre-intervention group and 200 caregivers and their children for the post-intervention group. Included children were aged 6–24 months with mild or moderate malnutrition (underweight and wasting) presented to the clinic during the study period (pre- and post-intervention), breastfed, non-breastfed, or wholly weaned.

Data collection tool

A structured questionnaire form was used during the exit interview with caregivers, derived from literature [8], [9], and included the following:

1. Sociodemographic characteristics: Age in years, sex, education, occupation, and residence.
2. Knowledge and practices of study participants regarding breastfeeding, complementary feeding, and nutrition during illness.
3. Client satisfaction with the different health services in the malnutrition clinic.
4. Source of knowledge.

Study intervention

The training package was designed according to the baseline assessment results (pre-intervention), and it was implemented through scheduled sessions. The theoretical and practical training courses included all the essential nutrition and feeding of infants and children and counseling skills that health-care providers should achieve and focused on the needs and gaps detected in the exploratory phase.

Conduction of the training course

The researcher conducted in-service training for health-care providers focusing on how to counsel the mothers on the proper child feeding practice guided by Integrated Management of Childhood Illness: Counsel the Mother handbook (2012) [10] and Practice guidelines for family physicians in Egypt.

Seven training days were completed; two sessions per week (training was completed in 2 months). Each session included all health-care providers; three physicians and two nurses currently working in the malnutrition clinic.

Software program for nutrition counseling

The researcher had introduced an innovative method to facilitate counseling, recording, and retrieval of data using wireless technology “Mobile Health” (Tablet) in the malnutrition clinic. The researchers developed a software program that improves quality and equity in providing nutrition counseling to all patients and overcoming the following challenges: A limited number of physicians and a high caseload limiting the time for providing quality services to all cases. The physicians’ high turnover and lack of standardization of provided services could vary across physicians.

Steps of software program development

1. Preparation step: In this step, we prepared the tablet case record form, the Excel sheet, and the content of the nutrition counseling messages after reviewing references on special studies addressing mobile health use in the health field, especially nutrition counseling.
2. Technical design of the software program: The application was built on a Ruby on Rails web framework, written in Ruby programming language. It is backed by a MongoDB database. Mainly, two database tables were used to generate the desired output; one stored pre-entered possible permutations of questions answered (those extracted from the Excel sheets) along with their diagnosis and the other table stored the actual records/answers provided by a physician. Once an answer is submitted, it is matched against the permutations. If a match was found, the diagnosis is shown on the screen and can be accessed later. For physicians’ convenience, the interface was designed to be computer and tablet friendly; this was achieved using a Zurb Foundation framework. The whole application is hosted freely on a service called AppFog. A web developer performed the technical design of the software program. The main modules of this software program were a database, diagnostic, and output modules. The software produces an output that displays the following: clinical nutritional diagnosis, tailored nutrition counseling for the caregiver based on diagnosis, and setting the next appointment date (after 1 week, 2 weeks, or 1 month according to the case condition).
3. Software testing: It is an integral and essential phase of the software development process.

4. Deployment: It started directly after the program is appropriately tested, approved, and after its installation, with periodic testing of its validity.
5. Standardization of practice in nutrition counseling: A software program had been loaded into a tablet that the physician could use simply.
6. Software training: The researcher had been prepared to be a trainer to physicians. The software is effective if it is used correctly.
7. Implementation: It is the part of the process where software engineers program the code for the project. After training the physician, who expressed appreciation for using the new technology in nutrition counseling, the physician started its use in the clinic. In the beginning, it was not easy to become acquainted with the new method. The researcher provided the physician with printed papers like the tablet screen display to be more familiar with the new form. After using the papers for 10 cases, the physician becomes at ease in using the tablet to record cases. Accordingly, data were recorded for 200 children who attended the malnutrition clinic seeking medical advice for 3 months (3 alternating days per week). Children with different diagnoses were included to examine a wide range of clinical conditions and nutritional needs with the competent items of nutrition counseling.

   Using the tablet checklist form, the caregiver must be asked about the following data for each visit of the enrolled child: Child background, milk feeding pattern, preparation of artificial milk and its serving (if applicable), feeding pattern and supplementations, child health, and family life. The child was subjected to the following procedures: Clinical examination, laboratory investigations (according to the physician's request), anthropometric measures, diagnosis, and treatment. According to the input and output data, the physician will provide the caregiver with specific nutrition counseling for her child and the next appointment date.
8. Supporting the health information system in the malnutrition clinic: Data recorded for each case have automatically recorded in an Excel sheet on the researcher's computer through the internet for periodic analysis and providing output on all cases examined and recorded on the tablet. Access to information in Excel through the internet is limited to those who officially have the password. Summary of information derived from Tablet-Internet-Excel program on 200 cases recorded by the malnutrition clinic physician.

The researcher organized the process of nutrition counseling within the malnutrition clinic to ensure proper time management and augmentation of the benefits of counseling received by caregivers. The cycle starts with the nurse, who receives the case and records the child's basic data, that is, weight and height/length. The caregiver goes to the physician who conducts nutrition counseling guided by the standardized software program. According to the specific nutrition issue derived from the articulation of data input (by the software program), the essential topic for nutrition counseling will be defined and discussed between the physician and the caregiver. The caregiver must go back to the nurse to get more information about specific nutrition guidelines for her child.

On-the-job training

Throughout 3 months, the researcher conducted four site visits/week to the malnutrition clinic to observe the performance of nurses in nutrition counseling. During each visit, the researcher tried to identify the misinformation provided by mothers. The researcher developed a daily list of misinformation and the correct information to be discussed and kept by the nurses to be committed for counseling with updated, correct information (Supplementary file 3; shows the developed list for updated information developed by the researcher for nutrition counseling to be used by nurses**).** Such a list within the clinic ensures the dissemination of updated information among nurses even in case of turnover.

Statistical analysis

The pre-coded data were entered and analyzed using the statistical package SPSS version 24. Categorical variables were expressed in percentages. Continuous variables were expressed as mean ± standard deviation. Statistical differences between groups (pre-post) were tested using. Chi-square test for qualitative variables and when cells had expected count <5, Fisher's exact test was used. Besides, an independent sample t-test was performed for quantitative normally distributed variables and a non-parametric test for non-normally distributed data. $p < 0.05$ was considered statistically significant [11].

Operational quantitative data analysis using the scoring system

Caregivers knowledge score

The researcher developed scores measuring caregivers' knowledge of breastfeeding, complementary feeding, malnutrition, feeding during illness and after recovery, and oral rehydration solution. For calculating the knowledge score, each correct answer (that corresponded with international recommendations) was given a score of 2, does not know was scored as 1, and an incorrect answer was given a 0 mark [12]. Knowledge score was estimated as the percentage

of the maximum achieved score for each question or group of questions out of the total elements at the group level.

Caregivers' practice score

The researcher developed scores measuring breastfeeding, complementary feeding, malnutrition, feeding during illness and after recovery, and oral rehydration solution-related practices among caregivers. For calculating the practice score, each correct practice (that corresponded with international recommendations) was given a score of 1, and the wrong practice was given a 0 mark. Practice score was estimated as the percentage of the maximum achieved score for each question or group of questions out of the total elements at the group level [13].

Results

The present study revealed that the tendency for the pre-intervention group (pre-IG) to have younger mothers (<30 years old) (80.0%) versus 69.0% of mothers related to the post-intervention group (p = 0.01). At the family level, the pre-intervention group, compared to the post-intervention group, had a relatively satisfactory socioeconomic background regarding the education of mothers and fathers (p < 0.001) and working for cash for both the mother and father (p < 0.05). However, the proxy indicator for family income expressed as the family's monthly expenditure indicated that more than half (56%) of post-intervention group families had a monthly expenditure of more than LE 1000 versus 32% of the pre-intervention group (p < 0.001).

Table 1 shows that a significantly higher proportion of the post-intervention group had correct answers regarding advantages of breastfeeding. There was a significant difference between the two groups regarding their knowledge about the disadvantages of artificial milk compared to breastfeeding. Contamination was mentioned by 87.0% of the post-IG versus 37.5% for the pre-intervention group. Regarding "Time to start breastfeeding," a significant proportion (84.5%) of the post-intervention group mentioned "Immediately after birth" versus 5.5% of the pre-intervention. Continuing breastfeeding up to the age of 24 months was mentioned by 91.0% of the post-intervention versus 48.5% for the pre-intervention group (p < 0.001). The knowledge score about breastfeeding was 34% among the pre-intervention group versus 73% among the post-intervention group.

Table 2 displays that caregivers in the post-IG reported significantly higher percentages than caregivers of the pre-IG regarding knowledge about proper child weaning for the items related to (weaning definition, type of food to be given as the first weaning food, number of light meals, and definition of proteins). On the other hand, the pre-intervention group reported significantly higher percentages than women of the post-intervention group for the items related to time of starting weaning and mentioning examples of dietary protein (p < 0.001).

Table 1: Comparison between pre- and post-intervention groups as regards caregivers' correct breastfeeding knowledge

Correct BF knowledge	Group				
	Pre-IG (n = 200)		Post-IG (n = 200)		p-value
	No.	%	No.	%	
Advantages of breastfeeding					
Support child immunity	158	79.0	193	96.5	<0.001
Easy digestion	30	15.0	199	99.5	<0.001
Protect mothers from diseases	29	13.5	144	55.5	<0.001
Disadvantages of artificial milk					
Contamination	75	37.5	174	87.0	<0.001
Difficult digestion	41	20.5	20	10.0	0.005
Low nutritional value	24	12.0	6	3.0	<0.001
Start breastfeeding immediately after birth	11	5.5	169	84.5	<0.001
Not serving fluids other than breast milk 3 days after birth	91	45.5	189	94.5	<0.001
Continuing breastfeeding till end of 2 years	97	48.5	182	91.0	<0.001
Breastfeeding on demand	127	63.5	187	93.5	<0.001
Knowledge score	1366	34%	2926	73%	<0.001

Table 2: Comparison between pre- and post-intervention groups as regards caregivers' correct weaning knowledge

Correct weaning knowledge	Group				
	Pre-IG (n = 200)		Post-IG (n = 200)		p-value
	No.	%	No.	%	
Definition of weaning	123	61.5	175	87.5	<0.001
Time of starting weaning (at 6th month)	98	49.0	40	20.0	<0.001
Type of food at start of weaning (cereals)	43	21.5	173	86.5	<0.001
Number of main meals per day (3–4/day)	79	52.0	67	33.5	<0.001
Number of light meals (yogurt, fruits) per day (1–2)	74	37.0	189	94.5	<0.001
Knowledge about proteins	85	42.5	195	97.5	<0.001
Mentioning examples of dietary protein (both animal and plant)	*55	64.7	**13	8.5	<0.001
Knowledge score	1114	43%	1704	61%	<0.001

* Out of 85.**Out of 195

Table 3 shows that the caregivers of the post-intervention group who participated in nutrition counseling reported significantly higher percentages than caregivers of the pre-intervention group for the items related to the association between malnutrition and morbidity as well as the mentioned malnutrition problems (p < 0.001). It delineates that the caregivers of post-intervention demonstrated significantly higher percentages than caregivers of the pre-intervention group for knowledge about nutrition-related items during child illness (p < 0.001). The total knowledge score was 7% among the pre-intervention group and 98% among the post-intervention group. Table 3 also highlights that the post-intervention group demonstrated significantly higher percentages than caregivers of the pre-intervention group for knowledge regarding items related to nutrition after recovery from child illness (p < 0.001).

Figure 1 demonstrates the impact of the study intervention on the knowledge status of caregivers regarding the nutrition of children in different age groups during illness and recovery. The knowledge score had increased from 27% (for the pre-IG) to 80% (for the post-IG) (Figure 2).

Table 3: Comparison between pre- and post-intervention groups as regards caregivers' correct knowledge about malnutrition, nutrition during child illness, and after recovery

Knowledge items	Group				
	Pre-IG (n = 200)		Post-IG (n = 200)		p-value
	No.	%	No.	%	
Knowledge about malnutrition					
Know the association between malnutrition and morbidity among children	96	48.0	191	95.5	<0.001
Mentioned malnutrition problems by mothers	(n = 96)		(n = 191)		
Rickets	18	18.7	154	80.6	<0.001
Anemia	34	35.4	100	52.4	<0.001
Underweight	32	33.3	107	56.0	<0.001
Knowledge score	360	37%	1104	71%	<0.001
Nutrition during child illness					
Increase breastfeeding	18	9.0	195	97.5	<0.001
Increase fluid intake	17	8.5	195	97.5	<0.001
More frequent eating	9	4.5	196	98.0	<0.001
Knowledge score	88	7%	1172	98%	<0.001
Nutrition after recovery					
Increase breastfeeding	46	23.0	192	96.0	<0.001
Increase fluid intake	18	9.0	193	96.5	<0.001
More frequent eating	18	9.0	196	98.0	<0.001
Knowledge score	164	14%	1162	97%	<0.001

Table 4 shows that the majority of children aged 6–23 months (83.0%) in the pre-intervention group are fed from the appropriate number of food groups according to their age group (three groups per day at 6–8 months of age and four groups per day at 9–23 months of age if breastfeeding), and 60.0% are fed the recommended minimum times per day (at least twice a day for breastfed infants aged 6–8 months and at least 3 times a day for breastfed children aged 9–23 months) in accordance with the WHO infant and young child feeding practice guidelines of the breastfed child [8].

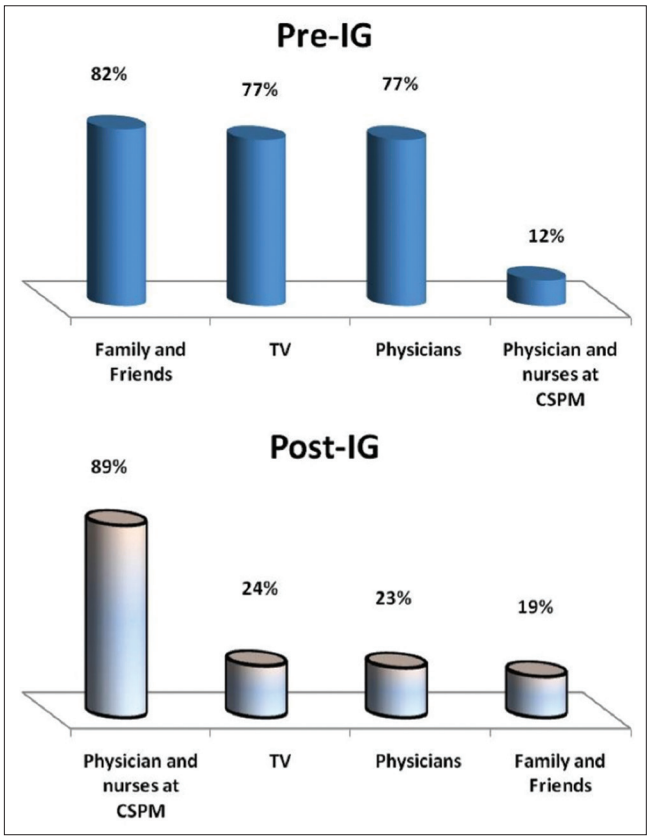

Figure 1: Children's nutrition knowledge among caregivers for the pre-IG and post-IG

For the post-intervention, most studied children (95.2%) received a standard number of food groups appropriate for their age, while the other half (47.1%) received the minimum recommended frequency in accordance with the *WHO infant and young child feeding practice guidelines of the breastfed child* [8]. Only 38% of the studied breastfed children were fed according to the recommended IYCF practices.

Table 5 reveals a significant difference between pre-intervention and post-intervention groups regarding the malnutrition clinic's reported child health-care services. The majority of the post-intervention group reported receiving the following health services; measuring body weight and length during the current visit ($p < 0.001$). The performance score had increased from 12% to 95%.

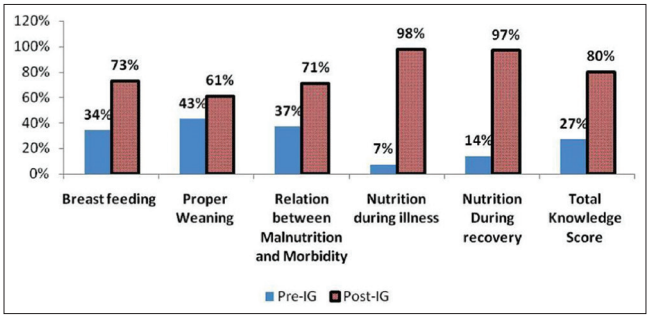

Figure 2: Rank ordering for the sources of information about children's nutrition for the pre-IG and post-IG

Table 6 revealed a statistically significant difference in the post-intervention group's communications and nutrition counseling services than the pre-intervention group. The performance score had increased from 48% before intervention to 90% after the intervention.

Table 7 illustrates the significant improvement in nurses' performance regarding children's growth monitoring. There was a statistically significant difference in nurses' performance in growth monitoring services between the pre- and post-intervention group ($p < 0.001$) and a marked increase in the performance score from 6% to 97%.

Discussion

The present study is applied research that provides information on how to promote the nutritional status of children aged 6–24 months attending malnutrition clinic through training of health-care providers on nutrition counseling of caregivers on child feeding-related knowledge and practices using both traditional method and an innovative technique using mobile health technology. Our study helped to show a possible pathway to improve child nutritional status by

Table 4: Percentage of youngest breastfed children aged 6–23 months in the pre- and post-intervention groups who were fed according to *IYCF feeding practices

IYCF practice	3+ food groups		Minimum number of times		Both (3+ food groups and a minimum number of times)	
	Pre-IG, n = 171	Post-IG, n = 187	Pre-IG, n = 171	Post-IG, n = 187	Pre-IG, n = 171	Post-IG, n = 187
Age in months		**		**		**
6–8	75.4	88.2	64.9	82.4	57.9	58.8
9–23	46.2	87.7	30.4	39.5	29.0	91.0
Sex		**		**		**
Male	81.5	95.8	67.7	47.9	61.5	39.4
Female	84.1	95.7	54.9	46.6	51.2	37.1
Mother's education		**		**		**
Illiterate	72.7	97.1	45.5	49.3	39.4	39.1
Some primary	29.8	18.1	22.0	8.0	21.0	5.3
Primary						
Secondary complete/higher	83.9	95.1	66.1	47.6	58.9	41.5
Total	83.0	95.2	60.0	47.1	55.8	38.0

*IYCF: Infant and Young Child Feeding Index **p ≤ 0.05 for all the groups

starting with health-care providers' training. Qualified health workers, such as medical physicians, nurses, nurse-midwives, nutritionists, and dieticians, can enhance feeding patterns, such as feeding frequency, dietary diversity, and calorie intake, among children aged 6 months–2 years, through in-service nutritional training [4]. When nutrition advice is offered by health workers who have received in-service nutrition training, it has been demonstrated to positively influence supplementary feeding and the nutritional status of children [14], [15].

Table 5: Comparison between pre- and post-intervention groups as regards the received services in the malnutrition clinic as reported by caregivers (anthropometric measurements and laboratory investigations)

Health services	Group				
	Pre-IG (n = 200)		Post-IG (n = 200)		p-value
	n	%	n	%	
Measuring body weight during current visit	23	11.5	188	94.0	<0.001
Measuring length during current visit	23	11.5	188	94.0	<0.001
Laboratory investigations in the past 3 months	28	14.0	191	95.5	<0.001
Performance score	74	12%	567	95%	<0.001

This articulated situation in the malnutrition clinic inflicted the researcher to introduce an "innovative approach in capacity building" [1]: Team approach in training physicians and nurses through traditional refreshing courses to have consistency and uniformity in the updated knowledge in children's nutrition [2]. On-the-job training of nurses to ensure coverage of all clients with the nutrition counseling package and periodic updating and correction of information and document such corrections to be a reference for nurses [3]. Use specially designed software loaded on a tablet to be used by the physician to record data for each case. The program overcame the lack of a growth chart at the secondary care level. The input data on weight and height automatically compare to the standard and produce the output as a nutritional status diagnosis. In addition, the program guides for health education are specific to each case with proper time management to overcome the problem of high caseload [4]. The establishment of the nutrition counseling cycle aligned the caregivers to guidance for child nutrition by both the physician and the nurse.

Table 6: Comparison between pre- and post-intervention groups as regards the received nutrition counseling services in CSPM

Performance	Pre-IG (n = 200)		Post- IG (n = 200)		p-*value*
	No.	%	No.	%	
Physician-client interaction					
Greeting	176	88.0	187	93.5	0.058
Allow for asking questions by the caregiver	166	83.0	200	100.0	<0.001
Respond to caregivers' questions	162	81.0	200	100.0	<0.001
Ensuring informed choices for management strategies	104	52.0	200	100.0	<0.001
Privacy during counseling	145	72.5	200	100.0	<0.001
Nutrition counseling					
Investigate the nutrition pattern of your child	103	51.5	200	100.0	<0.001
Identify malpractices in your child's nutrition	97	48.5	200	100.0	<0.001
Describing weaning	14	7.0	200	100.0	<0.001
Describing nutrition during illness	44	22.0	193	96.5	<0.001
Describing nutrition after recovery	32	16.0	192	96.0	<0.001
Follow-up visit scheduled	118	59.0	193	96.5	<0.001
Performance score	1161	48%	2165	90%	1161

Assessing caregivers' knowledge was essential in the current study to facilitate the development of effective strategies and interventions based on bridging any defects detected during the exploratory phase. The present study revealed that caregivers' level of knowledge before and the knowledge just received after exposure to physicians, nurses, and education material during the pre-intervention phase was 39% for knowledge score and 44% for practice score. Therefore, a tailored intervention to improve caregivers' knowledge will positively impact quality practices in children's nutrition.

Table 7: Comparison between pre- and post-intervention groups as regards services received from nurses in the malnutrition clinic

Performance	Group				
	Pre-IG (n = 200)		Post- IG (n = 200)		p-value
	No.	%	No.	%	
Nurses' performance in growth monitoring services					
Explain the growth monitoring in general	16	8.0%	196	98.0	<0.001
Explain findings related to the growth monitoring of your child	16	8.0%	192	96.0	<0.001
Understanding the growth monitoring findings	3	1.5%	193	96.5	<0.001
Performance score	35	6%	581	97%	

The present study considered mobile health technology the best intervention as a communication channel with caregivers attending the malnutrition clinic to disseminate information about appropriate child feeding. According to Barnett *et al*., cell phone counseling would work during pregnancy and lactation,

which are unique phases to reduce high morbidity and mortality [16]. Another feature that could support health services in the malnutrition clinic was the software program developed by the researcher with the help of an information technology specialist. The program instructed health personnel on screening a child for malnutrition, giving underweight youngsters nutrition recommendations, and when to return for follow-up (in a particular number of days or if particular symptoms occur). The software will recommend referring a child to a higher-level facility in cases of severe malnutrition classification or danger indications.

The recorded data in the tablet provided a database for the management information system to monitor performance at the malnutrition clinic. The development of the database of the recorded cases could validate the evaluation of service provided and serve the researchers in the faculty of medicine as one of the missions of the malnutrition clinic.

In Egypt, despite the enthusiasm about mobile phone technology, reviewing the literature found no studies that critically assessed the application of mobile phone technology for nutrition. There was little or no integration into national nutrition strategies or programs in Egypt, and there was little or no sustainability or chance for projects to grow. Most projects stopped when donor money ran out.

The present study considered introducing a new model within the current system of service delivery that fulfilled the requirements of sustainability: Enabling the policy environment through the involvement of the clinic staff (institutional sustainability), involvement of the service providers (financial sustainability), creating the culture of medical community participation to satisfy the needed resources for quality improvement (demand sustainability), and providing a model that demonstrates responses to caregivers' demands to be satisfied with services.

Across all the study outcome variables, significant post-intervention improvements were reported. First, in-service nutrition training improved health-care providers' nutrition knowledge. Second, the counseling skills and competence of health workers were also improved. Third, the training intervention improved caregivers' knowledge about child feeding practices. Fourth, the intervention was associated with improved child malnutrition management practices. Furthermore, the services received after intervention were appreciated as receiving knowledge from the clinic physicians and nurses and receiving all the components of quality nutrition counseling and clinical services during one visit to the malnutrition clinic.

It was evident from the results that women who participated in nutrition counseling reported significantly higher percentages than women in the pre-intervention group. There was an overall significant improvement in knowledge scores of caregivers after receiving nutrition counseling ($p < 0.001$), improvement in knowledge scores involved breastfeeding, complementary feeding, feeding during and after illness, malnutrition, and total knowledge score. In other words, the study intervention improved knowledge about breastfeeding and weaning by 3-fold and 4-fold respectively, for the post-intervention group compared to the pre-intervention group. The positive effect of educational intervention on nutrition knowledge and practice of the caregivers has been shown by several studies [17].

An essential parameter in nutrition care service is related to the background of the children. There was a significant difference in the socioeconomic background, feeding pattern, and disease/malnutrition pattern for the pre- and the post-intervention group. This indicated that the malnutrition clinic receives heterogeneous groups with a wide spectrum of nutrition problems. The pre-intervention group had their families and friends as a major source of information about child feeding. This was in contrast to the findings revealed from the previous studies where health services rep [18]. Such a situation dictated the need for a highly dynamic proactive system for service delivery to cope with the frequently changing characteristics of the clients.

In the present study, the increase in knowledge and improvement in the content and counseling skills of health-care providers brought about by the training translated into an increase in knowledge among the caregivers. All the interviewed caregivers in the post-intervention group reported receiving nutrition education through personal communication with health-care providers. The physicians and nurses were the most critical source of health and nutrition education, as reported by the post-intervention group, and this was reflected in being taken in the place of clinical examination ($p <0.001$). The results were similar to other studies that showed that mothers could recall information provided by trained health workers [19].

The present study findings matched those of a study conducted in 40 primary health care centers in Ismailia, Egypt, which found a statistically significant difference in nutrition counseling communications and counseling abilities between qualified and unskilled physicians. Trained physicians outperformed inexperienced physicians in communication skills such as using simple, straightforward language, confirming the moms' understanding, and offering practical assistance. Trained physicians gave considerably superior advice on supplemental feeding, including the correct number and volume of feeds and the composition of the child's meals [19].

Conclusion

Participation of a team of service providers in five articulating interventions for nutrition counseling (refreshing course, on-job training of nurses, booklet on proper infant and child feeding, software (e-health) program uploaded for physicians, and counseling cycle in the clinic) contributes to improving the performance of health-care providers and the quality of nutrition care services delivered to children. The use of mobile technology contributed to improving the quality of nutrition care services delivered in the malnutrition clinic.

Limitations of the study

The level of communication skills varied across the service providers. Due to differences in experience and work duration, there were variations across service providers regarding their interest toward the new intervention (training on nutrition counseling and use of tablet).

Service providers were overloaded with work in the outpatient clinic. Therefore, the training was done through frequent visits – short time sessions. Unless encouragement and support the use e-health technology, in different medical settings, the intervention could lose its power for sustainability.

Declarations

Ethics approval and consent to participate

The study protocol was revised and approved by the Ethics Committee in the Public Health Department, Faculty of Medicine, Cairo University. All subjects were treated following the Helsinki Declaration of biomedical ethics. Informed consent was obtained after proper orientation of the participants regarding the study's objectives, the confidentiality of data, and the impact of the research.

Availability of Data and Materials

The datasets used and analyzed during this study are available from the corresponding author on reasonable request.

Authors' Contributions

MS has made substantial contributions to conception and design, data analysis and interpretation, and manuscript writing. MRS has made substantial contributions to data acquisition and writing the manuscript. FA, SB, and FE were involved in drafting the manuscript ("Methods" and "Results" section) and revising it carefully for important intellectual content and statistical analysis. All authors read and approved the final manuscript.

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