Original Article

The Effect of an Educational Application on The Quality of Life and Treatment Adherence in Mothers of Children with Congenital Heart Disease Undergoing Cardiac Surgery: A Randomized Clinical Trial

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Abstract

Background: The primary caregivers of children with congenital heart disease (CHD) after cardiac surgery at home are often their mothers. Therefore, the quality of life (QoL) and treatment adherence (TA) of mothers are crucial for the prognosis of these children. This study evaluated the impact of a mobile educational application on the QoL and TA in mothers of children with CHD undergoing cardiac surgery.

Methods: This randomized clinical trial was conducted on 72 mothers of children with CHD referred for cardiac surgery to Children's Medical Center Hospital, Tehran, Iran, from September 2023 to May 2024. Mothers were randomly assigned to intervention (n=36) and control (n=36) groups. The intervention group received the educational app upon discharge and used it for four weeks, while the control group received standard discharge education, which consisted of face-to-face education. Data were collected using a demographic form, the 36-Item Short Form Health Survey (SF-36), and the Modanloo Treatment Adherence Questionnaire at baseline and one month post-intervention. Data were analyzed using SPSS software version 26, with independent t-test, chi-square, and analysis of covariance. A significance level of $P<0.05$ was considered.

Results: At baseline, no significant differences were observed between the two groups in total score of QoL ($P=0.18$) and TA ($P=0.70$). One month post-intervention, the intervention group showed significantly higher total scores in QoL ($P<0.001$) and TA ($P<0.001$) compared to the control group.

Conclusion: Using mobile applications in home care education can significantly enhance the QoL and TA in mothers of children with CHD after surgery.

Trial Registration Number: IRCT20230816059164N1.

Keywords: Congenital, Heart defects, Mobile applications, Quality of life, Treatment adherence

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Introduction

Congenital heart disease (CHD) is defined as the structural abnormalities of the heart or large vessels that occur during fetal development. CHD is the most common type of congenital anomaly, affecting between 0.8% and 1.2% of live births.[1] In the past, survival rates for children with CHD were low. Thanks to significant advancements in medical treatments and surgical interventions, survival rates have improved dramatically, with more than 97% of these children reaching adulthood.[1, 2] Although survival rates have improved, these children still face challenges in growth, development, nutrition, and physical activity, affecting their quality of life (QoL). As a result, they continue to require ongoing care and support.[3-5]

The primary caregivers of children with CHD following cardiac surgery at home are typically their parents, particularly mothers. Therefore, the prognosis for children with CHD relies on maternal treatment adherence (TA) after discharge. Non-adherence to prescribed treatments can lead to complications that may significantly worsen the child's prognosis.[6] Managing a child with CHD requires continuous medical care, regular hospital visits, surgeries, and monitoring of the child's health. These responsibilities impose significant emotional, physical, and psychological demands on mothers.[7, 8] They should manage their children's complex medical needs, cope with uncertainty, and balance caregiving with other family and work duties. This heavy caregiving burden leads to feelings of exhaustion, anxiety, and isolation.[9, 10] Mothers of children with CHD experience declines in mental health and overall QoL, highlighting the need for comprehensive, family-centered care that supports both the child and primary caregiver.[7, 11] Previous research has identified maternal QoL as a key factor in the recovery of children with CHD, and further studies have been recommended to explore interventions that can improve the QoL in mothers of these children.[12, 13]

One of the main sources of stress and anxiety for mothers of children with CHD, contributing to reduced QoL and poor TA, is a lack of knowledge and caregiving skills.[11] Previous studies have demonstrated that educating mothers can be an effective intervention in enhancing their caregiving knowledge and skills, ultimately improving outcomes for children with CHD.[7, 14] Despite the recognized importance of educating mothers of children with CHD in caregiving skills,[6] several obstacles—such as limited human resources, time constraints, insufficient educational equipment, gaps in staff knowledge, and mothers' fears in the hospital environment—hinder the effectiveness of in-hospital education, often leading to unsatisfactory results.[15] Consequently, many mothers leave the hospital without the essential information needed to care for their children. A study in South Korea found that only 16.4% of parents of infants with CHD received adequate information about their child's care at discharge. In this study, 75.5% of parents expressed dissatisfaction with the available educational opportunities, and 97.1% indicated a need for educational resources accessible at home after discharge.[16]

Given the widespread use of mobile phones and advances in technology, virtual education delivered through mobile devices has been proposed as a solution to improve the quality of education for mothers.[11] Previous studies have examined the effectiveness of virtual education through social messaging platforms, such as WeChat and WhatsApp, and found that it positively impacts QoL and TA.[17, 18] However, using social messaging platforms for caregiving education presents challenges, such as the lack of specificity for patient education and high Internet usage requirements. To address these issues, the development of dedicated mobile applications has been recommended.[6]

Children with CHD require continued home care after discharge. As mothers are typically the primary caregivers at home, their QoL and TA are critical to the recovery of

children with CHD. Education is a proven intervention for improving the QoL and TA of mothers though it is often not adequately implemented in hospital settings due to various barriers. Therefore, it is important to explore effective and innovative educational methods. This study aimed to assess the impact of a home care educational mobile application on the QoL and TA in mothers of children with CHD.

Materials and Methods

This randomized clinical trial involved 72 mothers of children with CHD referred to Children's Medical Center Hospital, affiliated with Tehran University of Medical Sciences, Tehran, Iran, from September 2023 to May 2024. This study was conducted in the Surgery Department 2 of Children's Medical Center Hospital, which admits children requiring cardiac surgery. Following the surgical procedures, the patients are transferred to the open-heart intensive care unit. Once their hemodynamic condition stabilizes, they are transferred back to Surgery Department 2, where they are reunited with their mothers and prepared for discharge.

Based on a significance level of α=0.05, a power of 0.8, an expected attrition rate of 10%, the standard deviation of QoL reported by Edraki et al. (2014), and considering a mean difference of 10 in the QoL scores, the optimal sample size was calculated to be 36 participants per group using the following formula.[19] Participants were recruited through convenience sampling.

$$n = \frac{(z_{1-\alpha/2} + z_{1-\beta})^2 \times (s_1^2 + s_2^2)}{d^2}$$

$$n = \frac{(1.96 + 0.84)^2 \times (12.6^2 + 15.7^2)}{10^2} \approx 32$$

The inclusion criteria were having access to a mobile phone with the Android operating system; being able to read, write, and use a mobile phone; having a child aged 0 to 6 years with a confirmed CHD diagnosis; having a child undergoing heart surgery for the first time; and not having any underlying conditions or other chronic diseases in the child.

Exclusion criteria included unwillingness to continue participation at any point during the study, any condition preventing the mother from using the educational application (e.g., loss of mobile phone), and the child's readmission or death during the study.

Participants were allocated to the intervention and control groups using the block randomization technique. The researchers generated all six possible 4-block combinations of two letters A and two letters B (AABB, ABAB, BAAB, BABA, BBAA, ABBA). Using a table of random numbers, 18 blocks were selected, forming a sequence of 72 letters (A and B), with A representing the control group and B the intervention group. This sequence determined the allocation of participants. A separate researcher who was not involved in the intervention handled sequence allocation to prevent bias. A five-stage model named ADDIE (Analysis, Design, Development, Implementation, and Evaluation) was employed to develop the educational application.[20]

In the analysis stage, the research team collected appropriate educational content for the application.[21] They conducted an extensive literature review, examined discharge pamphlets provided to mothers, and consulted with mothers, nurses, and pediatric cardiology experts to identify educational needs. The educational content topics included maternal self-care, stress reduction techniques, home environment preparation, recognizing warning signs, post-discharge follow-up visits, medication administration, chest physiotherapy, surgical wound care, and nutritional guidelines (Table 1). Ten experts—including pediatric nursing professors, experienced nurses, and a pediatric cardiologist—reviewed the content to confirm its validity.

The design stage focused on optimizing the user experience of the application. Consultations were held with mothers and app

Table 1: Educational content topics of the application

Topics	Contents
Introduction	Introducing the application and its objectives, introducing the developers of the application, instructions on how to use the application
Self-Care of mother	Emphasis on the mother's role in the child's recovery process, encouragement for the mother to practice self-care, introduction of stress reduction techniques, and recommendations for exercise
Home Care Tips	Improving home conditions for the child, Necessary tools for providing effective home care, Introducing Warning signs, and the child's limitations
Follow-Up	Follow-up appointment times, required medical documents for the visit, and the time and location for obtaining a chest radiography and performing an echocardiogram, Important tips about Vaccination
Medications	Introduction of commonly used medications such as Lasix, Spironolactone, Hydrochlorothiazide, Propranolol, Digoxin, Captopril, and Sildenafil; providing information on drug side effects, and instructions on the timing and method of administration
Chest Physiotherapy	Introduction to chest physiotherapy, explanation of its necessity, instruction on how to perform chest physiotherapy, identification of the optimal times for its application, and visual demonstration of the areas for hand percussion
Wound Care	Explanation of the duration and process of surgical wound healing, instructions on bathing, limitations related to the surgical site, and the method of applying topical ointments
Nutrition	Explanation of the a proper diet, prohibited foods, and the method and amount of breastfeeding for infants

design experts on the app's visual features and how to make it more user-friendly.[21] Key design elements included attractive fonts, appropriate color schemes, adjustable text size and font, and effective use of images and multimedia content.[22]

In the development stage, based on the feedback from the previous phases, the research team developed a pilot version of the application using Android Studio and the Java programming language. Then, in the implementation stage, the pilot version was installed on the mobile phones of experts and mothers for a one-week testing period to identify any technical issues or errors in the educational content. After resolution of these issues, the final version of the app, named "My Heart," was prepared for distribution among the mothers. The app provided unrestricted access to all educational content after installation.

In the evaluation stage, its impact on the mothers' QoL and TA was evaluated to assess the effectiveness of the application. Both intervention and control groups received standard interventions, including an educational booklet and discharge education provided by hospital nurses. Both groups were also followed up through weekly telephone calls. The primary difference between the two groups was that the intervention group was provided with the educational application. The intervention group received the educational app upon discharge and used it for four weeks.

To minimize contamination bias, we installed the app on the mothers' phones on the day of discharge, reducing contact between the control and intervention groups within the research setting. Additionally, participants were informed that the primary aim of the study was to evaluate the app's effectiveness, and they were asked not to share the app with others until the study concluded.

Data collection was carried out by two different individuals at baseline and post-test. They sent the data to the statistical analyst independently. Group assignment was obscured by labeling the participants with letters A and B, ensuring that the statistical analyst was blinded to group allocation. Due to the nature of the intervention, it was not possible to blind the participants.

Data were collected on the day of discharge using paper questionnaires and at the end of the fourth week post-discharge using electronic questionnaires. Three questionnaires were used for data collection. Demographic Information Questionnaire included five questions about the mother's age, education level, employment

status, child's age, and child's sex.

To assess the QoL of the participants, we used the Short Form Health Survey (SF-36), which was developed by Var and Sherbon.[23] This questionnaire contains 36 items that assess eight different domains of health. Each dimension consists of 2 to 10 questions: physical performance (10 items), limitation in role performance due to physical reasons (4 items), pain (2 items), general health (5 items), fatigue or exhilaration (4 items), social function (2 items), limitation in role performance due to emotional reasons (3 items), and mental health (5 items). One item does not belong to any of the subscales but contributes to the overall score. This questionnaire consists of yes/no questions, three-point Likert scale questions, five-point Likert scale questions, and six-point Likert scale questions. In this study, raw scores for each dimension were transformed to a 0-100 scale. In our scoring algorithm, the lowest possible score in this questionnaire is 0 and the highest 100. The higher score indicates a higher QoL.[7, 19]

Previous studies have shown that the original version of this tool has acceptable validity and reliability.[24, 25] Montazeri et al. (2005) translated this tool into Persian. They reported a Cronbach's alpha of 0.70, which confirmed the reliability. They also showed that all correlation coefficients were greater than 0.4, which confirmed the convergent validity of this tool.[26] Also, Edraki et al. (2014) reported the Cronbach's alpha of this tool to be 0.91 in mothers of children with CHD, confirming its reliability.[19] In the present study, the Cronbach's alpha of this questionnaire was found to be 0.83.

The Modanloo Treatment Adherence Questionnaire was developed by Fatemi et al. (2018) and consists of 40 items in seven subscales: making effort for treatment (9 items), intention to take the treatment (7 items), adaptability (7 items), integrating treatment with life (5 items), sticking to the treatment (4 items), commitment to treatment (5 items), and indecisiveness for applying treatment (3 items). The items in this questionnaire are scored using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Items 33, 34, 35, 37, 38, 39, and 40 are scored reversely. The total score and the score for each subscale are determined by summing the item scores and converting them into a percentage.[27]

Fatemi et al. reported the Cronbach's alpha of this tool to be 0.92 and the interclass correlation coefficient 0.92, which confirmed its reliability. They confirmed face validity quantitatively and qualitatively. The content validity of this questionnaire was also confirmed qualitatively and quantitatively by calculating the scale-level content validity index (S-CVI), which was 0.914. Finally, the construct validity was confirmed using exploratory factor analysis, which resulted in the extraction of seven factors that explained 48.54% of the total variance.[27]

This tool had not been previously used for parents of children with CHD, so its validity and reliability were evaluated before being applied in this study. After obtaining permission from the developer of the questionnaire, we assessed the content and face validity qualitatively by 11 pediatric nursing experts and 10 parents of children with CHD. Modifications were made to the wording of the items to ensure that the tool would effectively measure maternal TA. A pilot study, involving a sample size of 30, was conducted to assess the reliability of the tool by calculating Cronbach's alpha. The participants in this pilot study were different from those in the main study. The overall Cronbach's alpha for the tool was 0.80, with all subscales showing values above 0.7.

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 26. The normality of data distribution was assessed by examining skewness and kurtosis and using the Kolmogorov-Smirnov test. Descriptive statistics were employed to summarize the data. Mean and standard deviation were reported for quantitative variables, while frequency and

percentage were used for qualitative variables. Inferential statistics were applied to compare the groups and evaluate the effectiveness of the intervention. Chi-square was used to compare categorical variables between the groups. An Independent t-test was used to assess differences in QoL and TA scores between the groups at baseline and one month post-intervention. Analysis of covariance (ANCOVA) was used to adjust the baseline scores.[28, 29] Therefore, in this study we used ANCOVA to assess the differences in post-test scores between the groups with the adjustment. The significance level was set at $P<0.05$.

Sampling was initiated after receiving ethical approval from the Ethics Committee of Tehran University of Medical Sciences (no. IR.TUMS.CHMC.REC.1402.085) and registering the study in the Iranian Registry of Clinical Trials (no. IRCT20230816059164N1). Written informed consent was obtained from all participants, who were also informed that their participation in the study was voluntary and that non-participation would not affect the quality of care they received. Participants' confidentiality was preserved. After the study, the educational application was also provided to the control group.

Results

Among 84 mothers of children with CHD, 12 were deemed ineligible to participate in the study. The remaining 72 mothers were randomly assigned to the two groups. Ultimately, 72 mothers (36 in each group) completed the study, and their data were analyzed (Figure 1).

The mean age of the mothers in the intervention and control groups was 28.61±3.54 and 28.17±4.54 years, respectively. The mean age of children in the intervention and control groups was 1.28±1.28 and 1.13±0.86 years, respectively. The results indicated no significant differences between the two groups in terms of demographic

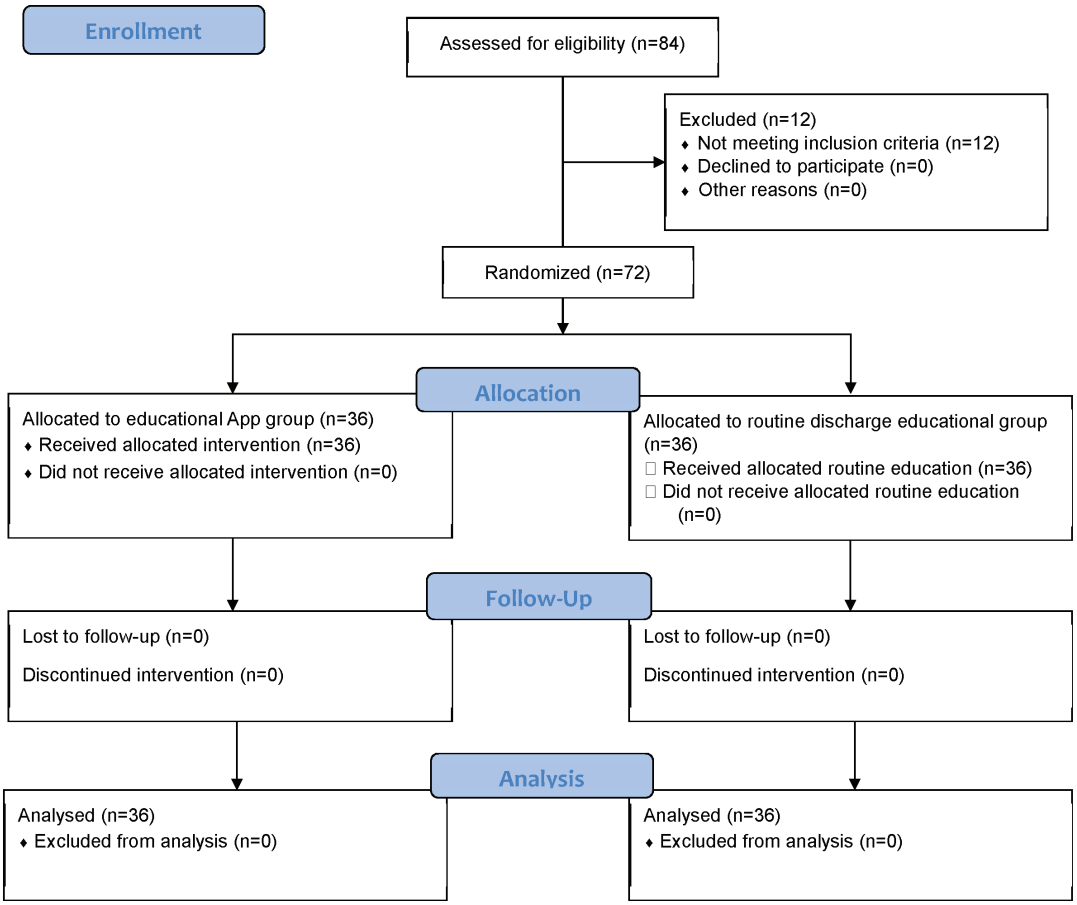

Figure 1: CONSORT flowchart of the study

Table 2: Comparison of the demographic characteristics of the participants between the control and intervention groups

Variable	Group		P value
	Control (n=36)	Intervention (n=36)	
	Mean±SD	Mean±SD	
Mother's Age (years)	28.61±3.54	28.74±4.54	0.64*
Child's Age (years)	1.28±1.28	1.13±0.86	0.56*
	N (%)	N (%)	
Child's Sex			0.81**
Boy	17 (23.6%)	18 (25%)	
Girl	19 (26.4%)	18 (25%)	
Birth Rank of the Child			0.75**
First	20 (27.8%)	18 (25%)	
Second	11 (15.3%)	14 (19.4%)	
Third	5 (6.9%)	4 (5.6%)	
Mother's Occupation			0.72**
Homemaker	31 (43.1%)	32 (44.4%)	
Employed	5 (6.9%)	4 (5.6%)	
Mother's Education Level			0.15**
Primary School	1 (1.4%)	7 (9.7%)	
Middle School	9 (12.5%)	8 (11.1%)	
High School and Diploma	16 (22.2%)	14 (19.4%)	
Above Diploma	10 (13.9%)	7 (9.7%)	

*Independent t-test; **Chi-square test

characteristics (P>0.05) (Table 2).

According to the independent t-test results, there was no statistically significant difference in the mean total QoL score between the intervention and control groups at baseline (35.26±13.22 vs. 34.04±14.30, P=0.18). One month after the intervention, a statistically significant difference in the mean total QoL scores was observed between the two groups (46.29±15.3 vs. 55.01±14.8, P<0.001). The results of the ANCOVA, after adjusting the baseline scores, indicated that the mean QoL total score in the intervention group was significantly higher than that of the control group one month after the intervention (P<0.001) (Table 3).

According to the independent t-test results, there was no statistically significant difference between the intervention and control groups in the mean TA total score at baseline (76.69±11.69 vs. 76.84±11.75, P=0.70). One month after the intervention, a statistically significant difference was observed in the mean TA total scores between the two groups (81.86±11.57 vs. 83.37±11.55, P<0.001). The results of the ANCOVA, after adjusting the baseline scores, showed that the mean TA total score in the intervention group was significantly higher than that of the control group one month after the intervention (P<0.001) (Table 4).

Discussion

The results of this study showed a significant improvement in the overall QoL in the mothers of children with CHD in the intervention group compared to the control group. Previous studies have highlighted the importance of educational interventions for caregivers of children with CHD and showed that providing mothers with appropriate training could improve their QoL.[6] Consistent with our findings, a study in Iran reported that a face-to-face educational program improved the QoL for mothers of infants with CHD.[19] Similar results from our mobile application suggest that this more accessible and flexible method could potentially replace face-to-face training. In contrast with our results, a study in Iran reported that a discharge education program did not improve the QoL of mothers caring for children post-cardiac surgery. The research team attributed the ineffectiveness of their intervention to the absence of psychological

Table 3: Comparison of the mean scores of the quality of life and its dimensions between the intervention and control groups before and one month after the intervention

Variable	Stages of study	Groups		P value*
		Control (Mean±SD)	Intervention (Mean±SD)	
Physical performance	Pre-test	37.91±5.84	38.12±6.79	0.88
	Post-test	67.36±10.03	68.75±9.28	0.54
	P value**	0.53		
Limitation in role performance due to physical reasons	Pre-test	20.83±13.52	21.00±15.68	0.96
	Post-test	45.83±24.27	50.69±24.99	0.40
	P value**	0.70		
Fatigue and exhilaration	Pre-test	16.53±7.54	16.94±6.35	0.80
	Post-test	26.04±6.25	44.44±12.02	<0.001
	P value**	<0.001		
Mental health	Pre-test	25.14±5.79	28.33±13.09	0.19
	Post-test	25.13±6.03	55.14±11.67	<0.001
	P value**	<0.001		
Social function	Pre-test	29.51±19.16	23.95±15.63	0.18
	Post-test	40.27±13.72	42.01±9.97	0.54
	P value**	0.47		
Pain	Pre-test	91.31±10.27	93.75±7.00	0.24
	Post-test	91.30±7.20	94.09±6.99	0.10
	P value**	0.14		
General health	Pre-test	40.69±6.77	41.39±6.61	0.66
	Post-test	40.70±5.36	41.53±7.44	0.58
	P value**	0.28		
Limitation in role performance due to emotional reasons	Pre-test	30.32±27.39	37.73±19.46	0.19
	Post-test	31.48±25.12	44.90±20.53	0.01
	P value**	0.02		
Total score of quality of life	Pre-test	34.04±14.30	35.26±13.22	0.18
	Post-test	46.29±15.37	55.01±14.87	<0.001
	P value**	<0.001		

*Independent t-test; **ANCOVA

support in their program.[7] Meanwhile, previous research has indicated that managing psychological needs and identifying adaptive coping strategies are major challenges for these mothers.[30] In our study, the mobile application included stress management techniques, which helped mothers better adapt to their child's condition, improving their mental health and ability to cope with emotional stress.

Previous studies on remote education for mothers of children with CHD have primarily utilized social messaging platforms. For instance, a study in China reported that education delivered via WeChat effectively improved the QoL in parents of children with ventricular septal defects (VSD).[31] Another study showed that educating parents of children with CHD via WeChat reduced their anxiety and depression and improved QoL.[17] In contrast to social messaging platforms, the mobile application used in our study did not require Internet access, making it more usable in areas without reliable connectivity, which is a significant advantage.

A closer examination of the dimensions of QoL revealed notable improvements in the dimension of fatigue and exhilaration for the intervention group. This result suggests that the educational application effectively reduced fatigue, which is important for mothers of children with CHD who face a significant caregiving burden. Our results also indicated improvements in the dimension of limitation in role performance due to emotional reasons, suggesting that mothers in the intervention group were better able to manage emotional stress post-intervention. Additionally, there was a marked improvement in the mental health

Table 4: Comparison of the mean scores of treatment adherence and its dimensions between the intervention and control groups before and one month after the intervention

Variable	Stages of study	Groups		P value*
		Control (Mean±SD)	Intervention (Mean±SD)	
Making effort for treatment	Pre-test	78.95±13.66	78.82±14.26	0.89
	Post-test	83.14±12.39	83.51±12.39	0.51
	P value**	0.49		
Intention to take the treatment	Pre-test	79.36±14.32	79.28±13.30	0.93
	Post-test	82.22±12.74	81.66±13.15	0.42
	P value**	0.43		
Adaptability	Pre-test	74.12±13.27	74.28±14.92	0.87
	Post-test	83.57±12.67	83.17±13.39	0.58
	P value**	0.32		
Integrating treatment with life	Pre-test	76.67±14.34	76.44±14.85	0.84
	Post-test	84.11±12.78	86.11±13.63	0.01
	P value**	0.01		
Sticking to the treatment	Pre-test	71.53±16.52	72.36±16.26	0.58
	Post-test	81.53±13.93	82.64±13.48	0.87
	P value**	0.16		
Commitment to treatment	Pre-test	71.22±13.80	71.67±14.09	0.63
	Post-test	72.33±10.49	74.22±10.53	0.44
	P value**	0.46		
Indecisiveness in applying treatment	Pre-test	85.74±6.20	86.48±7.55	0.65
	Post-test	85.95±10.17	86.29±10.07	0.87
	P value**	0.95		
Total score of treatment adherence	Pre-test	76.69±11.69	76.84±11.75	0.70
	Post-test	81.86±11.57	83.37±11.55	<0.001
	P value**	<0.001		

*Independent t-test; **ANCOVA

dimension for mothers in the intervention group. Educating mothers with appropriate training empowers them to provide better care for their children and fosters confidence about the future. This reduces anxiety and enhances their mental health.[6, 14] Consistent with our results, a study in China showed that post-discharge follow-up via WeChat alleviated anxiety and depression and improved QoL in parents of children with patent ductus arteriosus.[32] In another study, education and follow-up via WeChat were shown to be effective in improving knowledge, reducing anxiety, and enhancing QoL in parents of children with VSD.[33]

The results showed a significant difference between the intervention and control groups in overall TA scores post-intervention. TA is directly associated with caregiving knowledge and skills. Patient education is a proven strategy for improving TA.[34] By equipping mothers with caregiving skills, they become more competent and independent in managing their child's care, enabling them to integrate care routines into their daily lives and better adhere to treatment. In the current study, the educational application provided a flexible learning platform, allowing mothers to access educational content at their convenience, thereby improving TA. Easy access to educational content makes mobile applications effective tools for enhancing TA.[35] Similar to our results, a study in Iran showed that using WhatsApp to send educational materials to adolescents with CHD increased their TA.[18] Consistent with our results, in another study it was reported that mobile educational applications improved TA in elderly patients with hypertension.[22] A study in China demonstrated that using mobile applications improved medication adherence in patients with coronary heart

disease, where the research team used WeChat to send educational materials and a reminder application to remind participants about their medication doses.[36] In another study, a mobile application designed for adolescents with asthma, featuring educational materials and medication reminders, was shown to increase medication adherence.[37] Using alarms and reminders is an effective way to increase TA. While the mobile application in our study did not include reminders, it was still effective in improving TA.

The results of this study underscore the importance of integrating technology into patient education, especially for chronic pediatric conditions such as CHD. Nurses and healthcare providers should consider incorporating educational technologies like mobile applications into routine care for families affected by CHD. Doing so can enhance the mothers' understanding of their child's treatment regimen and self-care strategies, leading to better health outcomes for both mothers and children.

The strengths of this study lie in its rigorous design. Randomization minimized selection bias and ensured comparability between the groups, allowing for clear attribution of the intervention's effects. Blinding reduced the risk of bias in participant responses and outcome assessments. Efforts to minimize contamination between the groups ensured that the observed outcomes were directly influenced by the intervention. These methodological controls provide strong evidence of the effectiveness of the intervention.

This study had several limitations. One potential source of bias was the use of self-report methods for completing questionnaires. Additionally, data collection at baseline used paper questionnaires, while post-intervention data were collected electronically, which may have introduced bias. The variability in mothers' prior knowledge and skills in caregiving was unavoidable, and fully accounting for their differences at baseline was not feasible. Furthermore, influential factors such as the severity of the child's illness and the family's socioeconomic resources, both known to affect caregivers' QoL, were not controlled in this study. Although we attempted to address these potential confounders through randomization and adopting specific inclusion criteria, their impact cannot be entirely excluded. The effect of the intervention was assessed one month after discharge, and longer follow-up periods are necessary to evaluate its long-term effectiveness. Future studies should incorporate more follow-up assessments over extended periods. In this study, the mobile application was only compatible with Android devices, which led to the exclusion of some mothers. Future studies should design applications compatible with both Android and iOS platforms. Additionally, the application used in this study lacked interactive features such as notifications or communication with developers. Future patient education applications should include interactive elements such as notifications, communication options, and reminders to enhance user engagement. Although the mobile application provided comprehensive educational content, the absence of interactive features made it impossible to verify whether mothers correctly performed caregiving techniques, such as chest physiotherapy or stress management exercises, or fully engaged with all the educational materials. This limitation raises the possibility of improper technique execution or incomplete utilization of the application, which may have influenced the observed outcomes. To monitor the participants' adherence to and engagement with educational content, future educational applications should incorporate strategies such as in-app progress tracking or quizzes.

Conclusion

Our findings indicate that a mobile educational application effectively enhanced the QoL and TA in mothers of children with CHD following

cardiac surgery. By integrating technology into patient education, healthcare providers can offer better support to caregivers, ultimately improving health outcomes for both mothers and their children. Further research is needed to assess the long-term effectiveness of these interventions and their potential application to other chronic pediatric conditions. As technology continues to transform healthcare, adopting innovative educational tools will be crucial in addressing the complex needs of families navigating chronic illness.

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Authors' Contribution

RN and JB contributed to the conceptualization and design of this study. The data analysis and interpretation were carried out by MMR and RN. MMR and JB drafted the initial manuscript. All authors critically reviewed, revised , and approved the final version of the manuscript for publication. All authors take responsibility for the integrity of the data and the accuracy of the data analysis. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Declaration on the use of AI

The authors used OpenAI's ChatGPT to assist with language editing. All intellectual content, data analysis, and interpretations were performed by the authors, and the final manuscript was reviewed and approved by all authors.

References

1 Wu W, He J, Shao X. Incidence and mortality trend of congenital heart disease at the global, regional, and national level, 1990-2017. Medicine (Baltimore). 2020;99:e20593.
2 Mandalenakis Z, Giang KW, Eriksson P, et al. Survival in Children With Congenital Heart Disease: Have We Reached a Peak at 97%? J Am Heart Assoc. 2020; 9:e017704.
3 Maya S, Gunawijaya E, Yantie NPVK, Windiani IGAT. Growth, Development, and Quality of Life in Children with Congenital Heart Disease Children. Open Access Macedonian Journal of Medical Sciences. 2020;8:613-8.
4 Machado Amazonas BA, Guerreiro Vieira da Silva DM, de Souza Ribeiro MN. Nursing guidelines for caregivers of children with congenital heart disease after discharge: Integrative Review. Investigacion y Educacion en Enfermeria. 2023;41:e05
5 Dardas LA, Pan W, Hamdan AI, et al. Quality of life in Arab children with congenital heart disease. PLoS One. 2024;19:e0290306.
6 Begjani J, Nagarandeh R, Rajabi MM. Interventions to Improve the Quality of Life of Parents of Children With Congenital Heart Diseases: A Scoping Review of Randomized Clinical Trials. Iran Journal of Nursing. 2023;36:412-23. [In Persian]
7 Sabeti F, Safarkhanlo M, Abaszadeh R, et al. The effect of discharge planning on quality of life in mothers of children with congenital heart disease undergoing

surgery. Journal of Hayat. 2022;27:348-60. [In Persian]
8 Sanayeh M, Nourian M, Tajalli S, et al. Resilience and Associated Factors in Mothers of Children with Congenital Heart Disease: A Cross-Sectional Study. Int J Community Based Nurs Midwifery. 2021;9:336-45.
9 Cruz AC, Aranha GA, Silva CMC, et al. The complexity of having a child with a congenital heart defect in a developing country: A qualitative study of parental needs. Journal of Pediatric Nursing. 2022;64:e159-e65.
10 Nayeri ND, Roddehghan Z, Mahmoodi F, et al. Being parent of a child with congenital heart disease, what does it mean? A qualitative research. BMC Psychology. 2021;9:33.
11 Begjani J, Negarandeh R, Haghani S, et al. Design, Implementation, and Evaluation of an Educational Mobile Application for Home Care After Surgery of Pediatrics With Congenital Heart Disease: A Protocol Study. Iran Journal of Nursing. 2023;36:212-25. [In Persian]
12 Lee JS, Cinanni N, Di Cristofaro N, et al. Parents of Very Young Children with Congenital Heart Defects Report Good Quality of Life for Their Children and Families Regardless of Defect Severity. Pediatr Cardiol. 2020;41:46-53.
13 Bektas İ, Kır M, Yıldız K, et al. Symptom Frequency in Children with Congenital Heart Disease and Parental Care Burden in Predicting the Quality of Life of Parents in Turkey. J Pediatr Nurs. 2020;53:e211-e6.
14 Rodrigues MG, Rodrigues JD, Soares MM, et al. Improving the quality of life of parents of patients with congenital abnormalities using psychoeducational interventions: a systematic review. Quality of Life Research. 2023;32:3027-37.
15 Penchah S, Pourghane P, Nikfam M, et al. Exploration the Challenges of Patient Education from Nurses' Viewpoints: Qualitative Content Analysis. Education and Ethics in Nursing. 2020;9:9-16.
16 Lee BR, Koo HY. Needs for Post-hospital Education among Parents of Infants and Toddlers with Congenital Heart Disease. Child Health Nurs Res. 2020;26:107-20.
17 Zhang QL, Lei YQ, Liu JF, et al. Using telemedicine to improve the quality of life of parents of infants with CHD surgery after discharge. Int J Qual Health Care. 2021;33:mzab133.
18 Seraj B, Alaee Alaee-Karahroudi F, Ashktorab T, et al. The effect of telenursing on adherence to treatment in adolescents undergoing cardiac surgery. Cardiovascular Nursing Journal. 2020;9:100-10. [In Persian]
19 Edraki M, Kamali M, Beheshtipour N, et al. The effect of educational program on the quality of life and self-efficacy of the mothers of the infants with congenital heart disease: a randomized controlled trial. Int J Community Based Nurs Midwifery. 2014;2:51-9.
20 Spatioti AG, Kazanidis I, Pange J. A Comparative Study of the ADDIE Instructional Design Model in Distance Education. Information. 2022;13:402.
21 Saeidnia HR, Kozak M, Ausloos M, et al. Development of a Mobile App for Self-Care Against COVID-19 Using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) Model: Methodological Study. JMIR Form Res. 2022;6:e39718.
22 Baghei D, Poortaghi S, Sahebi L, et al. Effect of Mobile Educational Application on Adherence to Treatment in Elderly with Hypertension. Journal of Mazandaran University of Medical Sciences. 2022;32:114-24. [In Persian]
23 Ware J, Sherbourne C. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Medical care. 1992;30:473-83.
24 Jenkinson C, Wright L, Coulter A. Criterion validity and reliability of the SF-36 in a population sample. Qual Life Res. 1994;3:7-12.
25 Wu Q, Chen Y, Zhou Y, et al. Reliability,

validity, and sensitivity of short-form 36 health survey (SF-36) in patients with sick sinus syndrome. Medicine (Baltimore). 2023;102:e33979.
26 Montazeri A, Goshtasebi A, Vahdaninia M, et al. The Short Form Health Survey (SF-36): Translation and validation study of the Iranian version. Quality of Life Research. 2005;14:875-82.
27 Seyed Fatemi N, Rafii F, Hajizadeh E, et al. Psychometric properties of the adherence questionnaire in patients with chronic disease: A mix method study. Koomesh Journal. 2018;20:179-91. [In Persian]
28 O'Connell NS, Dai L, Jiang Y, et al. Methods for Analysis of Pre-Post Data in Clinical Research: A Comparison of Five Common Methods. J Biom Biostat. 2017;8:1-8.
29 Najmi A, Sadasivam B, Ray A. How to choose and interpret a statistical test? An update for budding researchers. J Family Med Prim Care. 2021;10:2763-7.
30 Dalir Z, Heydari A, Kareshki H, Manzari ZS. Coping with Caregiving Stress in Families of Children with Congenital Heart Disease: A Qualitative Study. Int J Community Based Nurs Midwifery. 2020;8:127-39.
31 Zhang QL, Xu N, Huang ST, et al. WeChat-assisted pre-operative health education improves the quality of life of parents of children with ventricular septal defects: A prospective randomised controlled study. J Paediatr Child Health. 2021;57:664-9.
32 Yang B, Liu JF, Xie WP, et al. The effects of WeChat follow-up management to improve the parents' mental status and the quality of life of premature newborns with patent ductus arteriosus. J Cardiothorac Surg. 2021;16:235.
33 Xie WP, Liu JF, Lei YQ, et al. Effects of WeChat follow-up management of infants who underwent ventricular septal defect repair on parents' disease knowledge and quality of life: A prospective randomized controlled study. J Card Surg. 2021;36:3690-7.
34 Paczkowska A, Hoffmann K, Kus K, et al. Impact of patient knowledge on hypertension treatment adherence and efficacy: A single-centre study in Poland. Int J Med Sci. 2021;18:852-60.
35 Ghozali MT. Innovations in Asthma Care: Efficacy of Mobile App-Assisted Patient Education in Promoting Asthma Self-Management. In: Bennett G, Goodall E, editors. In: The Palgrave Encyclopedia of Disability. London: Palgrave Macmillan, Cham; 2024.
36 Ni Z, Liu Ch, Wu B, et al. An mHealth intervention to improve medication adherence among patients with coronary heart disease in China: Development of an intervention. Int J Nurs Sci. 2018;5:322-30.
37 Ni Z, Wu B, Yang Q, et al. An mHealth Intervention to Improve Medication Adherence and Health Outcomes Among Patients With Coronary Heart Disease: Randomized Controlled Trial. J Med Internet Res. 2022;24:e27202.