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Efficacy of Using A Mobile Application in Support Of Postdischarge Compliance Among Heart Failure Patients

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Abstract

Background: New mHealth applications provide for enhanced adherence to self-care management regimens. However, such technology-based self-care interventions have not undergone consistent testing.

Methods: This mixed-methods study examined the efficacy of the Heart Failure Health Storylines (HFHS) mobile health application with discharged heart failure (HF) patients. The purpose was to determine how HF patients use the application to maintain self-care at home. Participants were randomized into an experimental group (n = 20) which used the HFHS application, and a control group (n = 20) which used discharge notes only. Quantitative methods identified confidence differences between the experimental and control groups. Qualitative methods investigated how participants managed self-care.

Results: Data triangulation showed that participants in the experimental group significantly improved their self-care activities compared to those in the control group. The HFHS application significantly increased the confidence of HF patients to engage in self-care activities.

Conclusion: The HFHS application is effective at assisting self-care maintenance for discharged HF patients. However, use of the application must supplement discharge instructions to improve patients' confidence in their ability to maintain and manage self-care effectively.

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Introduction

Heart failure (HF) is a complex clinical syndrome of multiple symptoms, functional impairments, and poor health-related outcomes [1]. Patients with HF are frequently hospitalized for cardiovascular conditions such as uncontrolled hypertension, ischemia, arrhythmias, congestion, and hypervolemia and non-cardiovascular comorbidities, despite therapeutic advancements [2]. According to Kilgore et al., 25% of HF patients are readmitted within 30 days. But more than 50% of HF-related readmissions are preventable if HF patients adhere to their management plans [3].

This study examined the effectiveness of using a mobile application at home after discharge. The researcher examined differences in HF patients' confidence practicing self-care management and maintenance. The experimental group used the Heart Failure Health Storylines (HFHS) application, and the control group did not. The question was whether use of the HFHS application aided self-care compliance among HF patients after discharge. The patients in the experimental group received instructions on how to use functions of the application to document self-care activities, and received daily reminders from the application to assist with practicing self-care activities. The HF patients in both the experimental and control groups received instructions from the discharge notes.

Background

Mobile Health (mHealth) technology is defined as the use of smartphones, tablets, and other mobile devices to deliver health care and preventative services [4]. Mobile-phone applications have not only yielded new interactive methods of communication between patients and healthcare providers, but also provided platforms for enhancement of adherence to self-care management [4]. Patients who are well informed and motivated to use mobile phone applications become involved in self-management activities [4]. About 50% of American people downloaded at least one health application to their phone in 2017, and 500,000,000 patients will be using mobile health

Use of mHealth has become a potential cost-effective aid for HF patients in in-home care settings [4]. In 2016, Self-Care Catalysts launched the HFHS application, developed in partnership with the Heart Failure Society of America [5]. The application can assist HF patients with self-care management, even for patients with low literacy, low health literacy, and limited smartphone experience [6]. Creber et al. [7] ranked this application in the top three mobile applications for helping HF patients monitor and track their symptoms. The HFHS application received the highest functionality score among 74 mobile applications identified as supporting self-care [5]. The application can optionally share information with a patient's support system and healthcare providers, and patients can choose what to track [5]. Users receive colorful graphics conveying vital signs, symptom monitoring, diet, and fluid intake, and can customize the application to send real-time reminders [5].

Heart failure

Heart Failure is a clinical syndrome caused by a structural and functional defect in the myocardium resulting in impairment of ventricular filling or ejection of blood [8]. The ejection fraction is the fraction of blood pumped out from the heart during each contraction [9]. The New York Heart Association (NYHA) classification divides HF into four classes from Class I, in which there are no symptoms and no limitations to ordinary physical activity, to Class IV, where there is severe limitation. Many patients can improve their ejection fraction if they comply with proper management and treatment plans [9].

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Self-Care management and maintenance for HF patients

Self-care management is vital to achieving the best patient outcomes, reducing mortality, and improving quality of life [10]. Self-care involves behaviors that promote and prevent exacerbation of symptoms [11]. Its core elements are maintenance, monitoring, and management [12]. Patients must follow a prescribed regimen of care by taking medication and keeping appointments with doctors [12].

An HF patient's healthcare team must support the patient's self-care throughout the transition that begins in the hospital and continues at home after discharge [13]. At the initial diagnosis, members of the team should explain the importance of self-care and daily monitoring of symptom [13]. Healthcare providers must also teach and guide patients to complete self-care activities in the hospital before discharge. A patient transitions successfully when they adapt self-care activities and apply them at home [13]. Although HF patients are responsible for the management of their own care, education and support received from healthcare professionals improves the effectiveness of self-care [14].

Self-care education reduces the risk of unplanned readmissions among patients with HF by 30% at 12 months [15]. Patients who engage in proper self-care have better quality of life, fewer readmissions, and lower mortality than those who engage in poor self-care [16]. Yet many patients find it difficult to follow self-care advice to monitor and recognize their symptoms [16, 17].

For a patient to understand their health status, they must know the disease process, risk factors, and treatments needed to promote health. Treatments for HF include weight monitoring, diet, fluid count, smoking cessation, and moderate or no alcohol use [12]. To function optimally, patients must obtain knowledge of at least two of the following: monitoring signs and symptoms; managing medication; enhancing problem-solving and decision-making skills for medical-treatment management; changing behavior related to physical activity; diet; and smoking [18].

Nonadherence to recommended treatment plans has been common among HF patients. Typically, 60% of HF patients do not adhere to their medication regimens, and 80% do not adhere to lifestyle recommendations [10]. Conceicao et al. [19] found that HF patients demonstrated better self-care behavior when they participated in in self-management education programs than when they did not.

Statement of the problem

Heart Failure clinical outcomes depend largely on how well patients carry out self-care practices at home and seek early care for symptoms [4]. But self-care practice has remained a challenge for patients and those working in patients' support systems and healthcare institutions [10, 20]. The post-discharge period is a time of vulnerability for HF patients. They must accurately report on their self-care behaviors to help healthcare providers make clinical decisions that can improve quality of life and reduce the need for hospitalization [21]. Despite receiving education on self-care, HF patients have remained repeat emergency-room visitors [22]. To avoid hospitalization and maintain quality of life, HF patients must recognize symptoms and respond to symptom exacerbation [21].

Use of mHealth technology to support daily activities is one way to reduce the stress of self-care for HF patients at home. No studies have investigated the use of the HFHS application to assess HF patients' compliance with self-care recommendations.

Purpose of the study

HFHS has features that can assist HF patients to track multiple symptoms and detect potential correlations between symptoms in different periods [7]. It can help HF patients stay on course with provider-recommended diet, continuing exercise routines, adhering to a scheduled medication regimen, and attending follow-up appointments.

The objectives of this study were to (a) determine how HF patients maintain their self-care by using the HFHS application after discharge from hospital; and (b) evaluate HF patients' confidence using the HFHS application to maintain their self-care after discharge from hospital.

Significance of the Study

More than 25% of the world's population has been diagnosed as having heart disease [23]. Between 2013 and 2016, an estimated of 6,200,000 adults aged 20 years and older had HF in the United States. As the population has continued to grow, the incidence of HF has continued to increase [24]. Researchers have predicted the prevalence of HF to increase to 8,000,000 cases by 2030 [25].

This growth of HF cases increases the utilization of healthcare services [25]. In 2012 HF cost the nation an estimated $30,700,000,000 for healthcare services, medications, and missed days of work [26]. Heidenreich et al. [27] projected total costs of HF to rise from $31,000,000,000 in 2012 to $70,000,000,000 in 2030. Reduction of the national financial burden of supporting HF patients depends on reduction of readmission rates.

Use of technology

Research has shown that use of mHealth applications has been changing how patients monitor their conditions, especially with regard to self-care maintenance and management [6, 28]. Many commercial mHealth applications have appeared on the market to support patients with bariatric surgery, cancer, cardiovascular disorders, chronic pain, diabetes, depression, infection associated with health care, HIV, bipolar disorder, schizophrenia, and other matters [7].

Although research has shown that mHealth applications can improve the self-care activities of HF patients [4]. Athilingam et al. [4] found that several mHealth applications for HF were underdeveloped, and encouraged app developers to collaborate with healthcare organizations and providers to align these applications with specific guidelines.

Theoretical model

The information–motivation–behavior (IMB) model includes three constructs that influence behavior changes: information and knowledge about a behavior; an individual's motivation to perform the behavior; and the behavioral skills necessary to perform the behavior [29, 30]. Researchers have used the IMB model successfully as a framework for HIV behavior interventions, chronic medical conditions, and diabetes care [4].

In this study, two different IMB milieus were compared: one in which patients received the discharge information only, and the other in which patients used the HFHS application that provided more information and more tools to engage in self-care.

In this application of IMB model, "information" equates to HF knowledge, "motivation" refers to daily reminders and feedback from a patient's healthcare team to enhance motivation, and "behavioral skills" refers to management of medication, weight, diet, fluids, and physical activity for persistent self-management of HF.

Knowledge gap

The researcher found no existing work on assessment of the efficacy of the HFHS application for monitoring self-care practice among HF patients after discharge.

Research questions

Two research questions guided the study:

1. What is the difference in the level of confidence regarding maintenance of self-care between HF patients using the HFHS application (experimental group) and HF patients receiving standard care (control group)?
- Hypothesis: There are such differences between these patient groups.
2. How do HF patients maintain their self-care by using the HFHS application (experimental group) or discharge instructions (control group) after discharge from hospital?
- This question was qualitative in nature, and so there was no corresponding research hypothesis.

Method

Participants were randomly assigned to either the experimental group (which received the HFHS application intervention) or the control group. A mixed-method, concurrent triangulation approach was used to collect and analyze qualitative and quantitative data and compare them to identify differences or similarities. In the interpretation phase, the qualitative and quantitative findings were integrated.

The study occurred in three phases. In the pre-test phase, participants were randomized into two study arms. The Self-Confidence/Efficacy Questionnaire [4] was used to measure baseline self-care activities among both groups.

Then those in the control group were advised to follow the discharge instructions they received from the hospital and from the researcher. The experimental group then received (a) HF education and discharge instructions, (b) guidance on downloading the HFHS application to their phones, (c) education on how to use the application, (d) patient demonstration of application, and (e) follow-up phone calls.

In the post-test phase, the participants from both groups completed another Self-Confidence/Efficacy Questionnaire via phone interviews [4] for the quantitative portion and answered eight open-ended questions for the qualitative portion.

Setting

The study took place at a cardiac clinic in Prince George's County, Maryland, and at patients' homes. As the location of the clinic was a predominantly African American area, all patients selected were African American.

Ethics approval

This study was approved by the Morgan State University Institutional Review Board. The researcher obtained permission to conduct the study from the cardiologist and informed consent from the participants. Data were protected in the computer that can be accessed only by the researcher with her own password.

Population and sampling

Potential participants were those scheduled to follow up with the cardiologist during February or March at the cardiologist's clinic in Prince George's County in Maryland. The NYHA HF classification [31] was used as a standard screening tool. To be included, a participant had to be aged at least 18 years; be able to read, write, and speak English; have a smartphone; have received a diagnosis of HF in Class I, II, or III; and not be awaiting a heart transplant. The Consolidated Standards of Reporting Trials flow chart [32] was used to assess HF patients' eligible for the study.

The recruitment period lasted for four weeks in 2021. 123 patients were eligible for the study, and 83 patients were scheduled to see the cardiologist during February or March. Out of the 83 patients scheduled, 40 patients consented to participate in the study. This sample was used for both portions of the study, as the concurrent design requires that the qualitative and quantitative portions have the same sample [33]. Each of the 40 participants was randomly assigned to either the control group or the experimental group. Chi-square tests on the sociodemographic and clinical characteristics of participants found no statistically significant differences between the two groups.

Data collection instruments

Qualitative and quantitative data were collected concurrently. Qualitative data came from eight open-ended questions to assess HF patients' home self-care practices. Questions were based on the relevant literature [34].

Quantitative data was gathered via the Self-Confidence/Efficacy Questionnaire [4]. The questionnaire was used to measure adherence to self-care recommendations and one's confidence in the practice of self-care. A five-point Likert scale was used to rate patient confidence in a variety of categories, with a score of five indicating the highest confidence. The self-efficacy-12 questionnaire showed evidence of content validity with a Cronbach's alpha of 0.95, a Loevinger's H coefficient of 0.71 and the test-retest reliability of 0.71 [35]. The Self-Confidence/Efficacy Questionnaire was designed to assess HF patients' confidence in their ability to use a mobile application, and the questionnaire showed good reliability for HF patients in Athilingam et al.'s study [4]. The researcher adapted and modified this questionnaire to suit the HF patients in this study.

Intervention

Both groups received the discharge packet [9]. The core components of the packet were the causes of HF, how to manage HF, how HF is treated, types of HF, ejection fraction, what patients should watch, medicine patients take, how to reduce sodium, avoiding hidden sources of sodium, diet and nutrition, how to change recipes, how to understand nutrition facts labels, smoking, how to manage weight,

how to become physically active, and keeping appointments with doctors. The control group received the discharge packet [9] only and they documented weight using a daily planner provided by the hospital.

The experimental group received additional information and instructions:

Protection of human subjects

- How to download the HFHS application based on their phone type.
- How to use features of the HFHS application to document self-care activities
- Guidance for entering cardiologist-prescribed medications—along with dosing times and dosages—into the application.

The experiment-group participants demonstrated use of the application to ensure their understanding, and received phone calls once a week to help ensure they practiced proper self-care at home and documented self-care activities in the HFHS application each day. The goal for the weekly phone calls was to motivate and engage participants in their self-care activities and encourage adherence to recommendations for behavior change. This group also received appointment reminders through the application, which those in the control group did not receive.

HFHS Application

The HFHS application can sync with a wide variety of fitness devices and applications [7]. It has features to track multiple symptoms simultaneously, which allows users to detect potential correlations between symptoms or patterns in symptoms over time. These data are displayed color-coded in a weekly calendar format so users can detect any changes [7].

The following features of the HFHS application, as described by Self Care Catalysts [36], correspond with 14 key self-management components in this study:

Daily weight: The vital-signs feature allows HF patients track and document their weight and their systolic and diastolic blood pressure. This feature presents graphical data to HF patients regarding their daily, weekly, or monthly progress, based on patients' preferences.

Medication: The medication scheduling feature reminds patients to take medication at prescribed doses and times. Rates of compliance with medication regimens among HF patients have been low [37]. Using an intervention to enhance patients' adherence to a medication regimen can significantly reduce readmissions and mortality [38].

Exercise: The physical-activity feature allows patients to track and document their physical activity using three predetermined levels, as well as the length of time spent exercising on any day.

Salt intake: High sodium intake is associated with exacerbation of HF symptoms and hospitalization [39, 40]. HF patients find reducing sodium intake difficult [41]. With the HFHS app, patients can describe foods they eat during the day. They can then see how much salt they can have consumed (1 teaspoon of table salt = 2,300 mg of sodium) or eliminate it from their diets.

Obtain salt information: To follow the low-salt diet, it is important that patients learn about the salt content of different foods, including by reading labels. With HFHS's low-salt diet feature, HF patients can find the types of food that are best to eat and avoid those with high salt content.

Fluid intake: The fluid/water tracker feature allows HF patients to record how much water they drink each day. Patients select a depiction of glass with (a) less than 250 ml of water inside; (b) 250 ml of water inside; or (c) 500 ml or more of water inside, and save this each time they drink water.

Keep doctor appointments: The appointment-calendar feature allows HF patients to add upcoming medical appointments or any other appointments, recording the dates and times scheduled and documents they must remember to take with them.

Shortness of breath: Difficulty breathing when lying down is a common symptom of HF [42]. Accumulation of fluid in the lungs can be gradual process, so the aim of management is to prevent congestion [43]. The weight-and-symptoms tracker feature allows HF patients to document shortness of breath on a scale of severity from 0 (low) to 10 (severe).

- **Additional features**: The application includes additional features to track or document smoking activity, meal portions, self-care reflections, health ratings, treatment reflections, diabetes foot care, and social contacts.

  Other important self-management behaviors that are not measured by the mHealth application include the following:

Check extremity swelling: Pedal edema is prevalent in adults with HF and can be a sign of congestive HF or other conditions such as kidney disease, liver disease, thyroid disorders, venous insufficiency, and venous thrombosis [44], but patients often do not recognize its relevance. Most patients do not perceive that worsening symptoms are intense enough to require hospitalization [45]. Delays seeking medical care are common among patients with worsening symptoms of HF and lead to longer hospital stays, increased healthcare costs, and increased morbidity and mortality [45].

Obtain health information: Inadequate knowledge and misconceptions can lead to lack of confidence and improper use of self-care skills [46]. Zeng et al. found a positive association between HF patients' knowledge about the disease and their compliance with treatment regimens, but identified knowledge deficits related to therapeutic regimens, symptoms of HF, and recognition of those symptoms [47]. McGreal et al. found that patients had low levels of knowledge and lacked a clear understanding of the causes of HF despite receiving HF education and information [48].

Follow treatment advice: HF patients struggle daily to balance self-care, and they can end up in hospital if nobody teaches them what to expect after discharge [49]. Antonicelli et al. reported that elderly HF patients complied better with therapy when undergoing home telemonitoring of compliance than when receiving usual care [50]. Telemonitored patients made more frequent use of statins and beta blockers, had lower cholesterol levels, and had higher reported health-perception scores [50].

Recognize change in health: Symptom recognition is a barrier to quality self-care management. Many patients fail to understand the signs and symptoms after discharge [49].

Relieve Symptoms: HF patients must self-monitor body changes, evaluate their meanings, respond to symptoms, and take action in a timely manner [49].

Change Self-Care: Patients need to be able to identify changes in their health and symptoms and adjust their self-care practices to address these.

Data collection

Before the intervention, participants from both groups completed a pretest consisting of 14-question Self-Confidence/Efficacy Questionnaire [4]. This data provided the baseline practice of self-care activities. For the quantitative data, the Self-Confidence/Efficacy Questionnaire [4] was administered via phone interviews on the first and second days of April 2021. Each interview lasted 20 minutes. The researcher read the questions over the phone, and participants were asked to select one answer on the 5-point Likert scale for each question: (1) not at all confident; (s) slightly confident; (3) somewhat confident; (4) moderately confident; and (5) very confident. Responses to the questionnaire were entered into a Microsoft Excel spreadsheet. For the qualitative data, eight open-ended questions were developed to capture concepts relevant to self-care activities HF patients must practice at home [34]. Participants were called by phone on the third and fourth days of April 2021 to collect qualitative data. Each interview lasted 20 minutes, and responses were documented on paper. These handwritten responses were entered into a Microsoft Word document. After the data were collected and transferred to computer, the computer was secured with a login password.

Data analysis

Data from the Microsoft Excel spreadsheet were imported into SPSS (Version 20). Pearson chi-square tests were then used to identify differences between the experimental and control groups regarding baseline practice of self-care activities.

After implementation of the interventions, participants from both groups were interviewed to assess their self-care skills during the study period, and to identify differences between the experimental and control groups. Thematic analysis was used to analyze qualitative data from the participants. The written notes of responses were read and reviewed for accuracy. The transcripts of the 40 interviews (20 each from the experimental and control groups) were imported into NVivo (Version 12). Three rounds of coding were conducted to answer the research question:

1. Open coding was used to analyze each sentence line by line to become familiar with the data. Content analysis was conducted to summarize and tabulate the frequencies with which various categories occurred.
2. In Vivo coding was applied, which places emphasis on the words spoken by the participants [51]. Additional codes were generated from the answers provided, and labels were assigned.
3. In Vivo codes were reviewed and similar codes collapsed together.

A total of 84 codes emerged from the interview data, 33 from the experimental group, and 49 from the control group. These codes were then organized into categories to identify patterns. Twelve themes emerged across six categories for both groups.

Quantitative Results

Pretest results

Table 1 displays the results of the pretest conducted using the 14-question Self-Confidence/Efficacy Questionnaire [52], which provided baseline data regarding participants' self-care management and maintenance. Each variable was measured for both the control and experimental groups. Pearson chi-square tests were used to compare the groups with respect to each variable when possible.

The pretest data overall indicated that participants were not confident about practicing self-care management or maintenance after discharge from hospital. Except for the matter of maintaining a low-salt diet, the data show no statistical difference between the two groups in practicing these self-care behaviors prior to the study.

Table 1: Pretest confidence results.

	Control		Experimental		Total	
Confidence	*f*	%	*f*	%	*f*	%
Daily weight (χ^2 = 0.000, *df* = 1, *p* = 1.000)						
1	10	50	10	50	20	50.0
2	10	50	10	50	20	50.0
Medication (χ^2 = 0.000, *df* = 1, *p* = 1.000)						
1	10	50	10	50	20	50.0
2	10	50	10	50	20	50.0
Exercise (χ^2 = 0.000, *df* = 1, *p* = 1.000)						
1	10	50	10	50	20	50.0
2	10	50	10	50	20	50.0
Low salt (χ^2 = 2.667, *df* = 1, *p* = .102)						
1	10	50	15	75	25	62.5
2	10	50	5	25	15	37.5
Obtain salt information						
1	20	100	20	100	40	100.0
Fluid Intake						
2	20	100	20	100	40	100.0
Keep doctor appointments						
2	20	100	20	100	40	100.0
Call doctor when short of breath						
2	20	100	20	100	40	100.0
Check extremity swelling						
1	20	100	20	100	40	100.0
Obtain health information						
1	20	100	20	100	40	100.0
Follow treatment advice						
2	20	100	20	100	40	100.0
Recognize change in health						
2	20	100	20	100	40	100.0
Relieve symptoms						
2	20	100	20	100	40	100.0
Change self-care						
2	20	100	19	100	39	100.0

Note. All tests two sided. Codes are 1 (*not confident*) and 2 (*slightly confident*).

Table 2: Post-test Confidence Result.

	Control		Experimental		Total	
Confidence	f	%	f	%	f	%
Daily weight (χ^2 = 11.760, *df* = 2, *p* = .003)						
3	9	45	1	5	10	25.0
4	11	55	14	70	25	62.5
5	0	0	5	25	5	12.5
Medication (χ^2 = 29.441, *df* = 2, *p* = .000)						
3	8	40	0	0	8	20.0
4	11	55	2	10	13	32.5
5	1	5	18	90	19	47.5
Exercise (χ^2 = 10.794, *df* = 2, *p* = .005)						
2	8	40	0	0	8	20.0
3	8	40	10	50	18	45.0
4	4	20	10	50	14	35.0
Low salt (χ^2 = 17.195, *df* = 2, *p* = .000)						
2	4	20	0	0	4	10.0
3	15	75	7	35	22	55.0
4	1	5	13	65	14	35.0
Obtain salt information (χ^2 = 16.810, df = 3, p = .001)						
2	5	25	0	0	5	12.5
3	13	65	6	30	19	47.5
4	2	10	11	55	13	32.5
5	0	0	3	15	3	7.5
Fluid Intake (χ^2 = 12.267, *df* = 3, *p* = .007)						
2	4	20	0	0	4	10.0
3	10	50	5	25	15	37.5
4	6	30	9	45	15	37.5
5	0	0	6	30	6	15.0
Keep doctor appointments (χ^2 = 27.143, *df* = 3, *p* = .000)						
2	9	45	0	0	9	22.5
3	6	30	0	0	6	15.0
4	5	25	9	45	14	35.0
5	0	0	11	55	11	27.5
Call doctor when short of breath (χ^2 = 5.796, *df* = 2, *p* = .055)						
3	11	55	4	20	15	37.5
4	7	35	10	50	17	42.5
5	2	10	6	30	8	20.0
Check extremity swelling (χ^2 = 5.767, *df* = 2, *p* = .050)						
1	1	5	0	0	1	2.5
2	15	75	9	45	24	60.0
3	4	20	11	55	15	37.5
Obtain health information (χ^2 = 32.762, *df* = 3, *p* = .000)						
2	1	5	0	0	1	2.5
3	19	95	2	10	21	52.5
4	0	0	14	70	14	35.0
5	0	0	4	20	4	10.0
Follow treatment advice (χ^2 = 10.952, *df* = 3, *p* = .012)						
2	1	5	0	0	1	2.5
3	9	45	2	10	11	27.5
4	9	45	10	50	19	47.5
5	1	5	8	40	9	22.5
Recognize change in health (χ^2 = 15.448, *df* = 2, *p* = .000)						
3	9	45	0	0	9	22.5
4	10	50	11	55	21	52.5
5	1	5	9	45	10	25.0
Relieve symptoms (χ^2 = 9.107, *df* = 2, *p* = .011)						
3	15	75	6	30	21	52.5
4	5	25	11	55	16	40.0
5	0	0	3	15	3	7.5
Change self-care (χ^2 = 18.727, *df* = 2, *p* = .000)						
3	11	55	0	0	11	27.5
4	9	45	13	65	22	55.0
5	0	0	7	35	7	17.5

Note: All tests two sided. Codes are 1 (*not confident*), 2 (*slightly confident*), 3 (*somewhat confident*), 4 (*moderately confident*), and 5 (*very confident*).

Post-test Results

The post-test was conducted to measure the effects of the interventions after the four-week study period. The analysis measured the effect of the independent variable (intervention type HFHS application versus discharge instructions) on the outcome variables for each of the 14 behaviors. Table 2 presents the data analysis for both groups.

Summary of quantitative results

The quantitative analysis based on the pretest results showed no significant differences between the groups. However, the analysis based on the post-test showed significant differences between the groups. This is summarized in Table 3.

Some of these results agree with previous studies on the use of mHealth apps. The significant difference in weight monitoring agrees with Wei et al.'s study of use of the Heart App, which showed a direct relationship between application use and weight change [53]. The significant difference in exercise agrees with Sharma et al.'s study regarding usage of the MyHeart Counts app [54] and the significant difference in maintaining a low-sodium diet reflects a previous study by Heo et al. involving the MyFitnessPal app [39].

In other areas, the significant differences between the two groups can be ascribed to regular reminders provided by the HFHS application. In the case of Relieving Symptoms, the HFHS application even provided day-to-day graphical presentations of participants' performance and displayed trends indicating symptom exacerbation. Such daily reminders also figure in the significant difference in Changing Self-Care.

In some areas where the HFHS application did not have a function, there was little or no significant difference between the two groups: Calling a Doctor and Checking Swelling. However, in two important areas not directly addressed by the HFHS application, there were nonetheless significant differences: Following Treatment Advice and Recognizing Changes in Health. This suggests that the HFHS application builds confidence in these areas through the various activities it does monitor and/or provide reminders.

Hypothesis

As hypothesized, participants who used the HFHS application expressed more confidence practicing self-care at than those who received standard care (the discharge instructions). The difference was statistically significant.

Qualitative results

Six themes were prominent across both groups, as shown in Table 4. There were no similarities between the groups, but there were differences. This indicates that the HFHS application, nurses' phone calls, reminders received from the application, and HF education influenced outcomes for participants in the experimental group and improved self-care among those participants.

Qualitative results

Six themes were prominent across both groups, as shown in Table 4. There were no similarities between the groups, but there were differences. This indicates that the HFHS application, nurses' phone calls, reminders received from the application, and HF education

Table 3: Differences between Experimental and Control Groups.

Behavior	Experimental vs Control	Chi-Square
Check weight	More confident	$\chi2 = 11.760$, $p = .003$
Take Medication	Significantly more confident	$\chi2 = 29.441$, $p = .000$
Exercise	Significantly more confident	$\chi2 = 10.794$, $p = .005$
Low-Sodium Diet:	Significantly more confident	$\chi2 = 17.195$, $p = .000$
Obtain Salt Information	Significantly more confident	$\chi2 = 16.810$, $p = .001$
Fluid Intake	Significantly more confident	$\chi2 = 12.267$, $p = .007$
Keep Medical Appointments	Significantly more confident	$\chi2 = 27.143$, $p = .000$
Shortness of Breath	No significant difference	$\chi2 = 5.796$, $p = .055$
Knowledge about HF	Significantly more confident	$\chi2 = 32.762$, $p = .000$
Check Swelling	No significant difference	($\chi2 = 5.767$, $p = .050$)
Obtain Health Information	Significantly more confident	$\chi2 = 32.762$, $df = 3$, $p = .000$
Follow Treatment Advice	Significantly more confident	$\chi2 = 10.952$, $p = .012$
Recognize Health Changes	Significantly more confident	$\chi2 = 15.448$, $p = .000$
Relieve Symptoms	Significantly more confident	$\chi2 = 9.107$, $p = .011$
Change Self-Care	Significantly more confident	$\chi2 = 18.727$, $p = .000$

Table 4: Comparing Themes of the Control and Experimental Groups.

Theme		
Topic	Control group	Experimental group
Medication	Conflicting use of medications	Using electronic reminders to improve medication adherence
Exercise	Difficulty maintaining exercise regimen	Consistency in adhering to daily exercise regimen
Shortness of breath	Inconsistent in monitoring shortness of breath	Compliance in monitoring shortness of breath
Weight	Not adhering to weight monitoring	Weight monitoring: preventing exacerbation through self-monitoring
Diet	Not complying with low-sodium diet	A healthy diet with low sodium
Water	Not complying with doctor's orders	Fluid management for positive outcomes

influenced outcomes for participants in the experimental group and improved self-care among those participants.

Use of medications

Participants made a total of 51 references to this theme. In the control group, most participants had difficulty taking medication. Comment included that they had "taken medication as remembered;" "sometimes forget to take doses the scheduled for morning in the afternoon;" having "challenges in compliance to medication;" and that they "sometimes remember to take medication at scheduled time."

Participants in the experimental group explained that use of the HFHS application supported, motivated, and aided them to take medication. Some responses indicated that the application was most beneficial for improving consistent adherence to medication regimes. Comments included that they liked "getting reminders every morning for all scheduled medications;" "It was very motivating to see my scheduled medication popping on my phone;" that the "app was interesting, sometimes if I forget to document after taken, it pops on the phone as missing medication, which prompts me to document;" and that "It felt good to have the support and the app was very engaging."

Maintaining an exercise egimen

More participants in the control group than in the experimental group experienced difficulty adhering to an exercise regimen because of work or because they did not feel like doing exercise. They suggested they needed support to engage in exercise, describing the regimen as hard and saying they needed help carrying out self-care [55]. One participant said, "That is tough, I get very tired by the time I get home." Participants were asked what could help them engage with activity. One participant responded, "Maybe, can walk if I do have someone to accompany me." Another participant said, "If I do have a dog to walk or have someone to encourage me to walk." A third participant responded, "I have a treadmill at home, but it is becoming more and more difficult to walk on it."

In the experimental group, the participants performed 30 minutes of exercise three or four times a week. The HFHS application asked

them to get moving and keep track of their home workouts. Participants had to document the duration and type of exercise they performed each day. The participants found physical activity important to do and understood the complications of immobility. Participants noted that exercise was something that could help them gain energy and live a healthy life, and believed it was necessary to follow their medical orders even if they felt they lacked the energy to do so. One participant said, "I do my exercise three to four times in a week." Another participant said, "I try to do my exercise in the morning before going to work." A third participant said, "I make sure to walk three to four times in a week after work."

Adherence to weight monitoring

The participants were asked whether they monitored their weight every morning.

Control-group responses show difficulty in keeping this practice:

"I do my best to drink the recommended fluid, but it is difficult to keep up with the amount consume every day."

"Well, I don't intentionally drink more than required but tend to drink more water during summer."

"I know the baseline of my weight, so I try to check it every week."

Participants understood the implications of their nonadherence to weight monitoring but refused to adhere nonetheless.

Patients in the experimental group recognized the need to weigh themselves every morning before leaving the house. Six participants' comments are as follows:

"I weigh myself every morning before going to work."

"I have a weighing scale at home, so it becomes much easier for me to get on and check my weight."

"My scale is in the bathroom, so it makes it much easier to check every morning before going to work."

"I document my weight using the mobile application."

"Mobile application gives me weekly reports so this enables me to track my weight if I'm doing good or poorly

"I use the app to document my weight every morning."

Because those in the experimental group could see graphic depictions of their weight every week, they could see whether they were doing poorly or well.

Monitoring shortness of breath

The participants had to note any shortness of breath, then determine whether taking diuretics was needed to eliminate excess fluid. Participants in the control group had difficulty monitoring shortness of breath. One participant said that they were "thinking that the shortness of breath will resolve." Other comments include

"I take the extra water pill, but it becomes difficult to reduce the amount of fluid intake."

"…the water pill makes me use the bathroom a lot."

"…taking extra water pill makes me wonder because I sometimes have accidents."

"I think it is not needed to call the physician right away for advice."

These participants understood the implications of not monitoring shortness of breath and not following advice received from their healthcare providers. They sometimes chose to ignore warning signs and not follow instructions to take an extra water pill, reduce water intake, and call a physician.

In the experimental group, five participants' comments include

"I use pulse oximetry to check my oxygen level."
"I do take another water pill and call my doctor for advice."
"I elevate my legs while sitting."
"I try to sleep on more pillows to prevent me from waking at night gasping for air."
"I try not to drink more fluids."

Compliance with a healthy low-sodium diet

Participants in the control group found it challenging to read food labels and follow a low-sodium diet by not consuming more than 1,500 mg of sodium per day:

"It is difficult to read label all the time when at the grocery store."

"Most of the items in the stores contains sodium and it is becoming more difficult to stick to recommended advice."

"I do sometimes crave for potato chips or pretzels, and I know it is not good for my health but eat it anyway."

"After my diagnosis, I try my best to eat often times at home, but sometimes I can't help myself from eating out."

"How do you get to measure how much salt in a meal every time you eat, this is insane."

These responses indicate that participants were not ready to comply with diet-related discharge instructions and were unready to change their behavior patterns.

The participants in the experimental group recognized the need to eliminate or reduce their salt intake as recommended by their healthcare providers. Remarks include

"I eat foods that have no salt, though it doesn't taste good."

"I used herbs and garlic to substitute my salt intake."

"I use herbs, spices, citrus juices, and vinegar instead of salt."

"Food without salt is tasteless so I try to garnish my food with herbs all the time."

Fluid intake

HF patients in the control group did not comply with recommendations regarding fluid intake. One participant said, "I did not count the cups and bottles drink." Another participant said, "I am advised to drink 1000 ml but difficult to consume." Few patients followed their doctors' recommendations for fluid management.

Those in the experimental group saw the need to drink the amount prescribed by their healthcare providers. For this group there was also a feature in the HFHS application to that allowed them to document fluid intake any time they had a drink and realize how much fluid they had consumed as the day progressed. This probably prompted participants in the experimental group to avoid exceeding the recommended intake. Comments include

"I drink 4 cups or 1,000 ml every day as recommended by my doctor."

"I drink 6 cups or 1,500 ml as advised by my doctor."

"I have to document how much I drink every day using the mobile application."

"This application helps me document how much I drink for each day."

"The app allows me to measure how much I drink every day."

Summary of qualitative findings

The qualitative findings revealed no similarities between the control and the experimental groups. Overall, those in the control group had difficulty following the self-care regimen, while those in the experimental group found it significantly easier.

Triangulation and Discussion

Triangulation of quantitative and qualitative data was used to identify points where the two methods agreed (convergence) or disagreed (discrepancy). Both sets of results consistently indicated that use of the HFHS application improved self-care in HF patients, while the qualitative responses elaborate details on how participants practiced self-care using either the HFHS application or just the discharge instructions. Participants in the experimental group highlighted the benefits of using the HFHS application in a home setting. The various features of the application enabled them to more easily practice self-care than those in the control group. Results indicate that use of the HFHS application significantly increased the confidence of HF patients to engage in self-care activities. This suggests that the HFHS application provides motivation to change behavior in the form of prompts, reminders, and education.

The results from the control group suggest that HF patients face challenges practicing self-care after discharge, but the results also suggest that providers could usefully introduce mHealth applications in the clinical setting before discharging patients.

For ethical reasons, participants in the control group were allowed to use the HFHS application to support self-care management at home after data analysis indicated that the application significantly improved the lives of those in the experimental group.

Conclusion

The HFHS application is effective at assisting self-care maintenance and management after discharge in patients with HF. The findings demonstrated a change in behavior that impacted health outcomes. This study introduced to HF patients types of motivation-use of the mHealth application in a remote setting, education, and nurse phone calls-that had positive health outcomes for the experimental group. However, use of the application must supplement discharge instructions to improve patients' confidence in their ability to maintain and manage self-care effectively at home after discharge.

Study implications

As stated earlier, self-care for HF can be difficult due to the many behaviors required. There was little existing research related to use of mHealth applications by healthcare providers in the United States. This study shows that use of this mHealth application improves patient self-care in all areas examined except checking swelling and calling a doctor when short of breath. The results of this study therefore have several public-health implications, and may aid the development of new strategies for incorporation into clinical practice.

Despite evidence supporting the use of mHealth applications by HF patients, healthcare institutions and providers have been slow to adopt the use of such applications. Incorporating mHealth applications that monitor symptoms, send reminders, provide education, and track trends in physiologic data can help patients practice effective self-care [56]. The HFHS application enables patients to engage with improvement of their health and wellness by staying on a provider-recommended diet, continuing exercise routines, adhering to a prescribed medication regimen, and attending follow-up appointments.

Many HF patients make frequent visits to the emergency room, and this application offers clinicians information about prescribed medications and improves communications. Use of the HFHS application can impact the growth of patient knowledge and patient adherence to self-care, which in turn can improve health outcomes and reduce readmissions rates and healthcare costs.

Limitations

This study did include some limitations. First, because the data were collected from African American HF patients living in Prince George's County, Maryland, the findings cannot be generalized to all HF patients in United States. Further research is needed to investigate HF patients from different places and who belong to different racial groups. Second, because this study relied on participants recruited from one clinic, further research is needed to investigate the use of the HFHS application in a hospital setting and determine its effect on HF patients' understanding of self-care before discharge. Third, the study did not involve investigation of the relationship between the use of the application and quality of life. Fourth, although the findings suggest that use of the HFHS application improved participants' confidence in self-care and compliance with recommendations during the 4-week study period, further research could focus on measurement of the efficacy of the application over a longer period. Fifth, the researcher did not assess whether participants received support to record self-care activities from relatives or friends. Sixth, hospitals information given to patients are written in grade level, further research could assess patients reading level before utilizing the HFHS application.

Strengths

Despite the limitations of this study, the study also had several strengths. The findings of this study contribute to gaps in existing literature regarding African American HF patients in Prince George's County, the largest and most affluent county in Maryland. Use of the HFHS application with HF patients was aimed at improving compliance with care recommendations in a remote setting. This intervention may help healthcare providers across Maryland, and possibly the United States, engage patients after discharge and can be incorporated into clinical guidelines as a means of addressing noncompliance with self-care recommendations.

Competing Interests

The author declares that he has no competing interest.

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