<Original Article>

Smartphone-Based Interventions for Heart Failure Self-Care Assessed Using the SCHFI or EHFScBS: A Scoping Review

Hiroko YAMAMOTO, and Itoko TOBITA

Graduate School of Nursing, Osaka Medical and Pharmaceutical University

Keywords: Heart failure, Self-care, Self-management, Smartphone applications

ABSTRACT

Heart failure requires sustained self-care, but maintaining effective self-management remains challenging for many patients. Smartphone-based interventions have gained attention; however, their characteristics, outcomes, and implementation challenges remain incompletely mapped. This scoping review aimed to identify the characteristics, reported outcomes, and challenges of smartphone-based interventions that assessed heart failure self-care using the Self-Care of Heart Failure Index or the European Heart Failure Self-Care Behaviour Scale. The review was conducted in accordance with PRISMA-ScR. PubMed, Ovid MEDLINE, CINAHL, and Scopus were searched through March 2026. Seventeen sources of evidence published between 2012 and 2025 were included. Most interventions were multicomponent, combining self-monitoring, education, reminders, feedback, motivational strategies, and communication with healthcare professionals. Self-care improved over time; however, significant between-group differences were not consistently observed. Reported supportive components included personalized support, motivational mechanisms, user-friendly design, and collaboration with healthcare professionals. Implementation challenges included technical support needs, differences in digital literacy, difficulties sustaining engagement, and concerns regarding data quality, privacy, and security. These findings may inform smartphone-based heart failure self-care support. Future research should examine long-term outcomes, identify effective components, and address safety, ethical, and data-governance requirements related to AI and wearable devices.

INTRODUCTION

Heart failure is a chronic condition characterized by impaired cardiac pumping function and affects an estimated 56.1 million people worldwide [1]. Its prevalence is expected to continue increasing because of population aging [2]. Heart failure is frequently accompanied by comorbidities such as chronic kidney disease, diabetes, and hypertension, which complicate disease management and are associated with poorer outcomes. In addition, heart failure places a substantial burden on healthcare systems because of frequent hospitalizations and high healthcare costs [2]. Therefore, effective self-care is essential for disease management and symptom control [3].

In heart failure, self-care refers to the process by which patients maintain their health, recognize symptoms, and respond appropriately to changes in their condition. Self-care consists of self-care maintenance, symptom perception, and self-care management [4]. However, many patients have difficulty recognizing worsening symptoms and responding appropriately, resulting in recurrent hospitalizations and reduced quality of life [5, 6]. Therefore, supporting self-

Address correspondence to:
Hiroko Yamamoto, Graduate School of Nursing, Osaka Medical and Pharmaceutical University, 7-6 Hachonishi-cho, Takatsuki-shi, Osaka 569-0803, Japan
Email: hiroko@koto.kpu-m.ac.jp

care remains an important challenge in heart failure management.

Recent advances in telemedicine and digital health technologies have increased interest in technology-based approaches to support self-care among patients with heart failure [7]. In particular, smartphone-based mobile health technologies, including applications, text messaging, and wearable device integration, have shown potential to support self-care in daily life [8]. Smartphone adoption has expanded rapidly in recent years, with approximately 49 % of the global population using smartphones [9]. In Japan, smartphone ownership has reached 97.2 % of households, and approximately 80 % of adults in their 70s own a smartphone. In contrast, ownership of personal computers and tablet devices has declined [10]. These findings suggest that smartphones are increasingly accessible, including among older adults, and may serve as practical tools for health management and self-care support.

Although an increasing number of studies have examined smartphone-based interventions supporting self-care in patients with heart failure, the characteristics, reported outcomes, and implementation challenges of studies assessing self-care using the SCHFI or EHFScBS have not been comprehensively mapped. The aim of this scoping review was to map and summarize the characteristics, reported outcomes, and implementation challenges of smartphone-based interventions for patients with heart failure that evaluated self-care using the Self-Care of Heart Failure Index (SCHFI) or the European Heart Failure Self-care Behaviour Scale (EHFScBS). In addition, this review sought to identify knowledge gaps and provide directions for future research on smartphone-supported self-care interventions assessed using these validated self-care measures.

Definition of Terms

In this review, self-care support was defined as smartphone-based interventions that actively engage patients in symptom monitoring, decision-making, or self-care behaviors.

MATERIALS AND METHODS

Study Design

This scoping review employed a scoping review methodology to systematically map and describe the existing literature on smartphone-based interventions for self-care in patients with heart failure. This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) [11].

The review addressed the following research questions:

1. What are the characteristics of smartphone-based interventions examined in studies assessing heart failure self-care using the SCHFI or EHFScBS?

2. What changes in self-care, as measured by the SCHFI or EHFScBS, have been reported in these studies?

3. What implementation challenges and considerations have been reported in these studies?

Selection and Exclusion Criteria

Studies were included if they: (1) involved patients with heart failure; (2) examined smartphone-based interventions designed to support self-care; (3) assessed self-care using the Self-Care of Heart Failure Index (SCHFI) [12] or the European Heart Failure Self-Care Behaviour Scale (EHFScBS) [13]; and (4) reported outcomes related to self-care. The eligibility criteria were intentionally restricted to studies using the SCHFI or EHFScBS because these validated, heart failure–specific instruments provide standardized and conceptually comparable assessments of self-care. Accordingly, studies that evaluated other relevant outcomes, such as medication adherence, symptom monitoring, self-efficacy, quality of life, heart failure knowledge, hospitalization, or healthcare utilization, without using either the SCHFI or EHFScBS were not eligible for inclusion. Interventions consisting solely of telephone calls, without a smartphone-based component, were excluded. Review articles, qualitative studies, study protocols, editorials, commentaries, and articles published in languages other than English were also excluded.

Search Strategy

The databases searched included PubMed, Ovid MEDLINE, CINAHL, and Scopus. Searches were conducted from database inception to March 20, 2026. The search strategy was developed in consultation with a health sciences librarian and initially designed for PubMed before being adapted for the other databases. The search terms were selected to reflect the review objective and to capture the core concepts of heart failure, self-care, and smartphone-based interventions. Accordingly, the search strategy focused on these concepts rather than broader digital health technologies. The complete search strategies for all databases are provided in Appendix 1–4.

Study Selection Process

All records identified through the database searches were imported into EndNote. Duplicate records were manually identified and removed by comparing bibliographic information, including titles, authors, publication years, and journal information. The remaining records were exported to Microsoft Excel for screening management. Two reviewers independently screened the titles and abstracts according to the predefined eligibility criteria. Records considered potentially eligible by either reviewer proceeded to full-text assessment. The same two reviewers then independently assessed the full-text articles for eligibility. Any disagreements arising during title and abstract screening or full-text

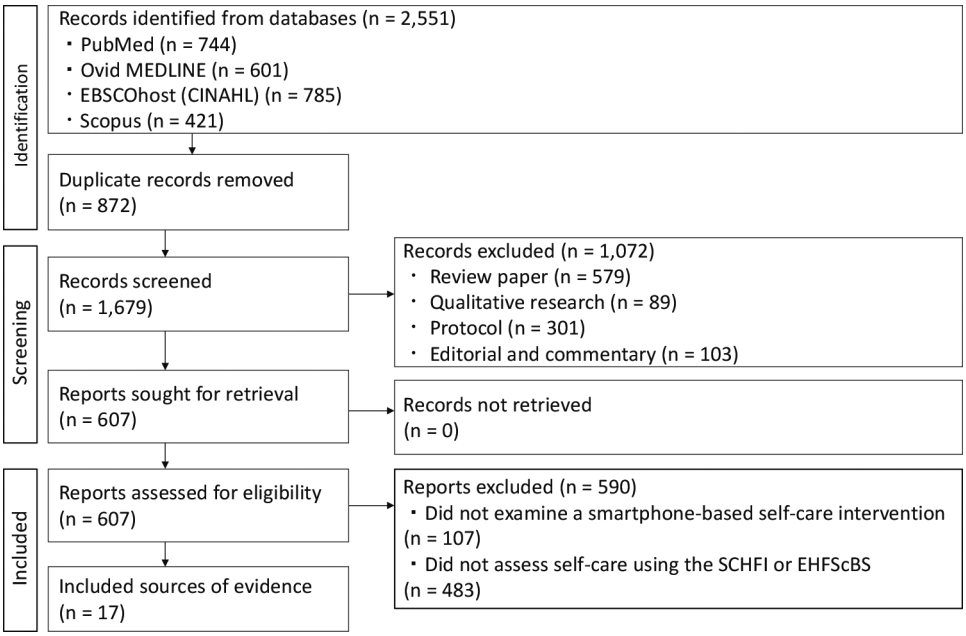


Figure 1 PRISMA-ScR Flow Diagram of the Literature Selection Process

assessment were resolved through discussion until consensus was reached. Reasons for exclusion at the full-text stage were recorded and summarized by category, with the corresponding numbers presented in the PRISMA-ScR flow diagram. The study selection process is presented in **Figure 1**.

Charting the Data

A data charting form was developed to extract key study characteristics, including the first author, year of publication, country, study design, sample size, intervention period, mean age of participants, self-care measures, timing of outcome assessment, intervention characteristics, conceptualization of self-care, and reported outcomes. Data charting was conducted independently by two reviewers, and any discrepancies were resolved through discussion until consensus was reached.

Data Collation and Synthesis

Extracted data were collated in Microsoft Excel and summarized descriptively in tables. Study characteristics, intervention characteristics, outcome measures, reported outcomes, and implementation challenges were examined across studies and organized according to the review questions. A descriptive and narrative synthesis was conducted to map the characteristics of the included studies and identify patterns and gaps in the existing evidence. No meta-analysis was performed.

RESULTS

Study Selection

Figure 1 presents the study selection process and results. A total of 2,551 records were identified through database searching. After removing 872 duplicates, 1,679 records remained for title and abstract screening. During the initial screening, 1,072 records were excluded because they did not meet the predefined eligibility criteria. The remaining 607 full-text reports were assessed for eligibility. Of these, 590 were excluded for reasons summarized in the PRISMA-ScR flow diagram. Ultimately, 17 sources of evidence met the eligibility criteria and were included in this review.

Characteristics of the Included Studies

The characteristics of the included studies are summarized in **Table 1**. The publication years were 2012–2014 for 2 studies, 2015–2019 for 1 study, 2020–2024 for 12 studies, and 2025 for 2 studies. The study designs comprised 10 randomized controlled trials, 2 nonrandomized controlled quasi-experimental studies, and 5 single-group pre–post studies. Several studies were further described as pilot, feasibility, proof-of-concept, repeated-measures, or mixed-methods studies. The mean age of the intervention group or overall group was 50–53 years in 1 study, 54–60 years in 8 studies, 61–64 years in 4 studies, and 65–71 years in 4 studies. The SCHFI and EHFScBS were used as assessment measures in 9 and 8 studies, respectively.

Sample Size and Intervention Duration

Sample sizes ranged from 9 to 162 participants: four studies included 9–20 participants, two included 25–30 participants, four included 51–80 participants, five included 81–110 participants, one included 120 participants, and one included 162 participants. The intervention duration was 4 weeks in two studies, 6 weeks in two studies, 2 months

Table 1 Characteristics of Included Studies

	Author (Year)	Country	Design	Sample size	Intervention period	Mean age	Self-care measure	Assessment time points	Intervention description	Result	Conceptualization of Self-Care
17	Seto et al. (2012) [16]	Canada	Stratified block randomized controlled trial	N = 100 (I = 50, C = 50)	6 months	I = 55.1 (SD 13.7)	SCHFI (v.4)	Baseline, post-intervention	Questions about weight, blood pressure, vital signs, ECG, and symptoms (answered with "Yes" or "No"), alert settings, and reminders for missed measurements	A significant difference was observed in the maintenance and management of self-care.	Behavioral adherence
13	Heiney et al. (2020) [17]	United States	Quasi-experimental pilot study with a one-group pretest–posttest design	N = 11	4 weeks	57.83 (SD 1.68)	SCHFI (v.6)	Baseline, post-intervention	(1) Reminders to weigh yourself every morning, (2) educational messages, (3) motivational messages, daily weight entry and answering questions about shortness of breath, alert messages in case of abnormalities, and graphing	We were unable to analyze self-care management. Although maintenance and confidence improved, there was no statistically significant difference.	Self-management
14	Kiyarosta et al. (2020) [18]	Iran	Randomized controlled trial	N = 120 (I = 60, C = 60)	3 months	I = 55.95 (SD 14.41)	12-item EHFScBS (score range: 12–60; lower scores indicate better self-care behavior)	Baseline, post-intervention (3 months)	Reminders, educational content, instructional videos, daily messages, medication guides, physical and mental symptoms along with vital signs and symptoms, a feature to record abnormal symptoms and warnings daily, and the ability to send encouraging messages to patients	The mean EHFScBS score was significantly lower in the intervention group than in the control group after the intervention ($p < 0.001$), indicating better self-care behavior.	Behavioral adherence
16	Vuorinen et al. (2014) [19]	Finland	Two-arm matched-pair randomized controlled trial	N = 93 (I = 46, C = 47)	6 months	I = 58.3 (SD 11.6)	12-item EHFScBS (score range: 12–60; lower scores indicate better self-care behavior)	Baseline, post-intervention	Using a mobile app to monitor blood pressure, weight, pulse, and symptoms (dizziness, shortness of breath, palpitations, weakness, swelling); the app provides automatic feedback based on the situation; if any abnormalities are detected, a nurse will call the patient.	The EHFScBS score decreased significantly from baseline in both the telemonitoring group (−5.0 points, $p < 0.001$) and the control group (−3.8 points, $p < 0.001$); however, there was no significant between-group difference in self-care behavior.	Behavioral adherence
6	Ware et al. (2022) [20]	Canada	Pragmatic randomized controlled trial with an embedded qualitative study	N = 96 HF 66, DM 5, HT, DM = 3 (I = 46, C = 50)	6 months	59.0 (SD 13.9)	SCHFI (v.6)	Baseline, 6 month	Body weight, blood pressure, and heart rate; a feedback function; alert settings for abnormal values; prompts to encourage clinic visits; and automated telephone call settings.	In patients with heart failure, a significant effect was observed in self-care maintenance; however, no significant difference was found between the two groups.	Self-management
2	Son et al. (2025) [21]	South Korea	Two-group quasi-experimental study with a pretest–post-test repeated-measures design	N = 70 (I = 35, C = 35)	6 months	70.67 (SD 11.48)	9-item EHFScBS (score range: 9–45; higher scores indicate better self-care behavior)	Baseline, 1 month, 3 months, 6 months	A chatbot application featuring symptom input; heart failure–related information; weekly individualized goals; guidance on diet and stress management; goal achievement elements (e.g., sunflower blooming and rankings); a mood diary; text messaging; peer groups with other patients and caregivers/family members; communication with nurses; feedback; data visualization (graphs); and reminders for medication and clinic visits.	The intervention group demonstrated significantly better adherence to self-care behaviors over 6 months than the control group (β = 4.68, 95 % CI 0.99–8.37).	Behavioral adherence
3	Son et al. (2023) [22]	South Korea	Single-center prospective pilot pretest–posttest	N = 26	6 months	62	9-item EHFScBS (score range: 9–45; higher scores indicate better self-care behavior)	Baseline, 6 months	Medication adherence/verification; clinic visits; symptom input; monitoring; sodium restriction; blood pressure; body weight; heart failure–related information; individualized goals; sunflower blooming (gamification element); chatbot; text messaging; feedback; and data visualization (graphs).	The median EHFScBS-9 score increased significantly from 27.0 (IQR 21.3–31.0) at baseline to 37.0 (IQR 35.0–43.0) after the 24-week intervention ($p < 0.001$), indicating improved self-care behavior.	Behavioral adherence
9	Bakogiannis et al. (2021) [23]	Greece	Nonrandomized controlled quasi-experimental study with repeated measures	N = 14	3 months	64.9 (SD 9.7)	9-item EHFScBS, transformed to a 0–100 scale (higher scores indicate better self-care behavior)	Baseline, 3 months	Body weight, blood pressure, and symptoms; medication reminders; weekly educational heart failure quizzes; gamification features; graphical displays; color changes to green upon data entry; and medal rewards when patients interact with the app.	The mean transformed EHFScBS score increased significantly by 4.4 points (SD 7.2) from a baseline mean of 64.2 (SD 10.2) after 3 months of app use (95 % CI 1.7–7.1, $p = 0.002$), indicating improved self-care behavior.	Behavioral adherence
1	Kitsiou et al. (2025) [24]	United States	Phase 1 feasibility and pilot randomized controlled trial	N = 25 (I = 11, C = 14)	2 mouths	56 (SD 8.3)	SCHFI (v.7.2)	Baseline, 4 weeks, 8 weeks	Medication reminders; blood pressure and body weight monitoring (line graphs, text feedback, alerts for abnormal values, and color-coded indicators); heart failure symptom tracking; provision of information on sodium-restricted diets; use of the Fitbit app (daily self-monitoring of step count, physical activity intensity, heart rate, and sleep); and individualized text messages sent four times per week.	A significant difference was observed between the self-care maintenance and self-care management groups. Symptom perception improved in both groups from baseline to 4 weeks; however, no significant difference was found between the two groups.	Heart failure self-care is a decision-making process centered on three interrelated concepts: self-care maintenance, symptom perception, and self-care management.

Table 1 (continued) Characteristics of Included Studies

	Author (Year)	Country	Design	Sample size	Intervention period	Mean age	Self-care measure	Assessment time points	Intervention description	Result	Conceptualization of Self-Care
8	Clays et al. (2021) [25]	Belgium, Italy	Randomized controlled proof-of-concept trial	N = 56 (I = 34, C = 22)	6 months	63.1 (SD 10.5)	SCHFI (v.6)	Baseline, 6 months	Body weight, blood pressure, heart rate, and body temperature; individualized exercise plans; lifestyle advice on nutrition; medication reminders; and an expert system providing psychological support (including elements of cognitive behavioral therapy and mindfulness exercises).	Self-care maintenance improved significantly only in the intervention group; however, no significant difference was observed between the two groups. Self-care confidence was not affected.	Behavioral adherence
7	Reif et al. (2022) [26]	Germany	Single-group pilot pre–post study	N = 64	3 months	61.81 (SD 10.73)	9-item EHFScBS, transformed to a 0–100 scale (higher scores indicate better self-care behavior)	Baseline, 3 months	Medication reminders; blood pressure, pulse, SpO_2, body temperature, and body weight; graphical visualization of vital signs; health status displayed using traffic light color-coding (feedback); and a function that prompts medical consultation when results deviate from the normal range.	The mean transformed EHFScBS score increased significantly from 63.32 (SD 17.02) at baseline to 69.92 (SD 11.90) after the 3-month intervention, with a mean increase of 6.60 points ($p = 0.01$), indicating improved self-care behavior.	Behavioral adherence
11	Dorsch et al. (2021) [27]	United States	Prospective, single-center, open-label randomized controlled trial	N = 83 (I = 42, C = 41)	3 month	I = 60.2 (SD 9)	SCHFI (v.6.2)	Baseline, 6 weeks, 12 weeks	Notification functions to promote daily self-monitoring; body weight; color-coded alerts (green, yellow, and red); and educational content.	Both the app group and the non-app group (standard care) showed improvements in all measures. There were no significant differences between the groups.	Self-management
5	Son et al. (2023) [28]	South Korea	Explanatory sequential mixed-methods pilot study with a one-group pretest–posttest design	N = 100 (I = 50, C = 50)	6 months	58.78 (SD 8.83)	9-item EHFScBS (score range: 9–45; higher scores indicate better self-care behavior)	Baseline, 1 month, 3 months, 6 months	Medication reminders; appointment dates for hospital visits; symptom monitoring; sodium restriction; blood pressure, body weight, and pulse; data visualization (graphs); interactive text messaging (69 questions and 108 responses) delivered three times per week; a chat application; and weekly goal setting, with a sunflower displayed on the screen upon goal achievement.	The intervention group had significantly higher EHFScBS-9 scores than the control group at 1, 3, and 6 months (all $p < 0.001$), with a significant group-by-time interaction ($p < 0.001$), indicating improved and sustained self-care behavior.	Behavioral adherence
15	Athilingam et al. (2017) [29]	United States	Pilot feasibility randomized controlled trial	N = 18 (I = 9, C = 9)	4 weeks	53.06 (SD 4.02)	SCHFI (v.4)	Baseline, post-intervention	Medication reminders, daily weight tracking, symptom assessment, personalized alerts, vital sign monitoring, graphs, automated reminders tailored to the patient, color-coded warnings, animated exercises, feedback to encourage walking, heart failure education (what is heart failure, low-sodium diet, exercise therapy, medication)	Improvements were observed in all areas.	Self-Management and Motivation
10	Jiang et al. (2021) [30]	Singapore	Three-arm stratified randomized controlled trial with repeated assessments	N = 162	6 weeks	I = 69.08 (SD 10.51)	SCHFI (v.6.2)	Baseline, 6 weeks, 3 months, 6 months	Educational information; medication reminders; body weight, blood pressure, and symptoms; and a chat room for communication with a research nurse.	Self-care maintenance, self-care confidence, and self-care management were all significantly different compared with the control group across all assessments.	Specific health behaviors that patients perform independently to manage their disease and maintain well-being.
12	Jiang et al. (2020) [31]	Singapore	Single-group pre–post repeated-measures pilot study	N = 9	6 weeks	69.7 (SD 11.04)	SCHFI (v.6)	Baseline, 6 weeks	Heart failure educational materials, fluid intake reminders, medication reminders, appointment reminders, weight, blood pressure, symptoms, chat room.	There was a significant difference in self-care maintenance and self-confidence.	Treatment adherence, symptom assessment, symptom management
4	Choi et al. (2023) [32]	South Korea	Non-blinded randomized controlled trial	N = 74 (I = 36, C = 38)	3 months	I = 70.31 (SD 10.55)	12-item EHFScBS (score range: 12–60; higher scores indicate better self-management behavior in this study)	Baseline, 3 months	Educational materials using photographs and animations; a daily health diary (including blood pressure and body weight, exercise and dietary status, medication intake, and signs or symptoms of deterioration); chat and Q&A functions; and daily monitoring of records by three nurses, who provided reminders and feedback.	The mean EHFScBS score increased from 41.17 (SD 6.85) to 48.14 (SD 6.07) in the intervention group and from 44.16 (SD 7.47) to 47.12 in the control group after 3 months. A significant time effect was observed ($p < 0.001$), but the group-by-time interaction was not significant ($p = 0.141$).	Behavioral adherence

in one study, 3 months in five studies, and 6 months in seven studies.

Outcome Measures and Timing of Assessment

Two validated instruments were used to assess self-care behaviors in patients with heart failure: the Self-Care of Heart Failure Index (SCHFI) and the European Heart Failure Self-Care Behaviour Scale (EHFScBS) [14]. The SCHFI version 6.2 consists of 22 items and three scales: self-care maintenance, self-care management, and self-care confidence. Responses are scored using 4-point Likert scales, and each scale score is standardized to range from 0 to 100, with higher scores indicating better self-care. A score of 70 or higher is commonly interpreted as adequate self-care [12]. The SCHFI was subsequently revised as version 7.2, which consists of 29 items across three scales: self-care maintenance, symptom perception, and self-care management [15].

The original EHFScBS is a 12-item self-administered questionnaire assessing heart failure self-care behaviors, including daily weighing, fluid restriction, and contacting a healthcare professional in response to weight gain [13]. Each item is rated on a 5-point Likert scale, producing a total score ranging from 12 to 60; under the original scoring procedure, lower scores indicate better self-care behavior. The scale was subsequently revised to a 9-item version, with raw scores ranging from 9 to 45. Across the included studies, the scoring procedures varied according to the version and scoring method used. Some studies reported scores in the original direction, whereas others used reverse scoring or transformed scores to a 0–100 scale so that higher scores indicated better self-care. Therefore, the version, score range, and scoring direction used in each study were extracted and are reported in **Table 1**. Findings were interpreted according to the scoring procedure reported in the original study and were described consistently in terms of improvement, no significant change, or worsening in self-care behavior.

Regarding the timing of assessment, self-care behaviors were assessed at two time points in 12 studies, at three time points in 2 studies, and at four time points in 3 studies.

Characteristics of Smartphone-Based Self-Care Interventions for Patients with Heart Failure

All included studies used multicomponent interventions delivered through smartphone or mobile phone applications. The method of providing the application varied across studies. In earlier studies, participants were generally provided with study smartphones on which the application had been pre-installed, whereas more recent studies commonly installed the application on participants' own smartphones.

Personalized Support

Interventions were implemented using chat rooms where patients could interact with nurses and receive interactive text messages. Heiney et al. [17] and Kiyarosta et al. [18] provided individually tailored text messages, including daily messages of encouragement to patients. Some interventions incorporated a telephone function, and Vuorinen et al. [19] introduced a system allowing nurses to call in the event of anomalies. Ware et al. [20] provided an automated telephone function.

Motivation Mechanisms

A sunflower appeared on the screen when a goal was achieved [21, 22], medals were awarded when patients operated the app [23], and reward messages were sent when goals were met [24]. Clays et al. [25] found that the program provided professional psychological support, including elements of cognitive-behavioral therapy and mindfulness, and was designed as a "safe" place for patients to learn about their illnesses and improve their health and well-being.

User-Friendly Design

In all studies automatic transmission of vital signs and feedback, alert warnings, medication reminders, and medical appointment reminders were the main features [26, 27]. Some of the alert warnings used color-coded visual indicators such as red, yellow, and green. Vital signs were graphed and served as visual feedback [16, 17, 21–24, 26, 28, 29].

Collaboration with Healthcare Professionals

The smartphone-based interventions supported collaboration between patients and healthcare professionals through symptom monitoring, sharing of patient-generated health data, and professional feedback. Heart failure symptoms, including shortness of breath, edema, and fatigue, as well as physiological and behavioral data, were monitored and recorded through the applications. Healthcare professionals used or reviewed these data to provide education and individualized support regarding sodium restriction, nutrition, exercise, medication use, and other self-care behaviors. Athilingam et al. [29] provided animated exercise guidance and feedback to encourage walking. Kitsiou et al. [24] used the Fitbit app to support patients' daily self-monitoring of steps, physical activity intensity, heart rate, and sleep as part of a healthcare professional–supported intervention.

Reported Outcomes of Smartphone-Based Self-Care Interventions for Patients with Heart Failure

Reported Outcomes Based on the SCHFI

The SCHFI included 9 studies, all of which reported improvements in self-care outcomes following the intervention. In particular, 4 studies showed significant between-group improvement [16, 24, 30, 31]. Significant improvements were also observed in self-care management in four studies [16, 24, 29, 30]. Further, interventions

that combined multiple components, such as applications and home visits [30, 31], reported the maintenance of self-care management ($p < .05$, $p < .025$). The use of reminder features [16, 24, 29, 30] reported improvements in medication-related self-care behaviors, and self-care confidence significantly improved in five studies [16, 24, 29–31]. Symptom perception improved from baseline to 4 weeks in both groups; however, there were no differences between the groups [24]. In a study utilizing this application, the total self-care index score increased from 186.1 to 198.1 at 6 weeks but was 196.9 at 12 weeks [27]. The minimum intervention period was 1 month, and the maximum was 6 months.

Reported Outcomes Based on the EHFScBS

Eight studies assessed self-care behavior using the EHFScBS. Three studies used the 12-item version [18, 19, 32], and five used the 9-item version [21–23, 26, 28]. Scoring procedures varied across studies. In Kiyarosta et al. [18] and Vuorinen et al. [19], lower scores indicated better self-care behavior. Four studies used scoring procedures in which higher raw scores indicated better self-care behavior [21, 22, 28, 32], whereas two studies transformed the EHFScBS-9 scores to a 0–100 scale, with higher scores indicating better self-care behavior [23, 26].

Kiyarosta et al. [18] reported significantly better self-care behavior in the intervention group than in the control group after the intervention ($p < 0.001$). In Vuorinen et al. [19], EHFScBS scores decreased significantly in both the intervention and control groups, indicating improvement, but no significant between-group difference was observed. In Choi et al. [32], scores increased in both groups over 3 months, with a significant time effect ($p < 0.001$), but the group-by-time interaction was not significant.

Son et al. [21] reported significantly better adherence to self-care behaviors in the intervention group over 6 months than in the control group. Son et al. [28] found significantly higher EHFScBS-9 scores in the intervention group than in the control group at 1, 3, and 6 months, with a significant group-by-time interaction (all $p < 0.001$). Son and Kim [22] reported a significant increase in the median EHFScBS-9 score after the 24-week intervention ($p < 0.001$). Reif et al. [26] and Bakogiannis et al. [23] also reported significant increases in transformed EHFScBS scores, indicating improved self-care behavior.

DISCUSSION

This scoping review mapped the characteristics of smartphone-based interventions for patients with heart failure in studies that assessed self-care using the Self-Care of Heart Failure Index (SCHFI) or the European Heart Failure Self-care Behaviour Scale (EHFScBS). By focusing on these validated, heart failure–specific instruments, the review delineated a specific body of evidence in which self-care outcomes were assessed using standardized measures. Therefore, the findings should be interpreted as representing studies using the SCHFI or EHFScBS, rather than the full range of smartphone-based interventions addressing heart failure self-care. A literature search on smartphone-based interventions to support self-care in patients with heart failure yielded a relatively small number of studies ($n = 17$). However, the number of studies published after 2020 increased to 14, indicating that the topic has been gaining attention in recent years, and research is expected to increase in the future. The included studies conceptualized heart failure self-care in different ways. Some studies primarily focused on adherence to recommended behaviors, such as medication use, sodium and fluid restriction, exercise, and daily self-monitoring, whereas others also emphasized symptom recognition and decision-making in response to changes in health status. These differences may partly reflect the distinct dimensions assessed by the EHFScBS and SCHFI. Therefore, differences in the conceptualization and measurement of self-care should be considered when comparing findings across studies.

Reported Outcomes of Complex Smartphone-Based Interventions

Application-based heart failure education increases patients' understanding of the disease, initiates behavior, and improves self-care [25]. The results of this review also indicate that complex interventions using smartphone applications are associated with improvements in self-care among patients with heart failure; in particular, the integration of vital-sign recording, medication reminders, educational content, psychological support, and communication features with healthcare providers promoted appropriate self-care behaviors.

However, improvements within intervention groups did not consistently translate into significant between-group differences in the included randomized controlled trials. Several methodological and clinical factors may explain these findings. First, many studies had relatively small sample sizes, particularly pilot and feasibility trials, which may have provided insufficient statistical power to detect modest intervention effects. Second, intervention and follow-up periods were often short, potentially limiting the time available for patients to incorporate newly learned behaviors into their daily routines and for measurable differences between groups to emerge. Third, intervention intensity and actual engagement varied across studies because the interventions differed in the frequency of reminders, feedback, monitoring, and communication with healthcare professionals. In multicomponent interventions, inconsistent use of individual components may have diluted the overall intervention effect.

Baseline self-care levels may also have influenced the

findings. In studies in which participants already demonstrated relatively adequate self-care at baseline or received structured heart failure management as part of usual care, the potential for further improvement may have been limited by ceiling effects. In addition, control groups may also have improved through usual care, study participation, repeated assessment, or increased awareness of self-care behaviors, thereby reducing between-group differences. Finally, the SCHFI and EHFScBS assess different dimensions of self-care and may not be equally sensitive to short-term or component-specific behavioral changes. Therefore, the absence of a statistically significant between-group difference should not necessarily be interpreted as evidence that the smartphone-based intervention had no effect; rather, it should be considered in relation to study power, intervention exposure, baseline self-care levels, comparator conditions, follow-up duration, and the measurement properties of the selected outcome instrument.

In addition, functions that support smooth communication with healthcare providers may facilitate self-care. For example, chat functions with nurses and interventions that enable two-way communication via text messages serve as practical and convenient means of facilitating communication between patients and healthcare providers [32], which can increase patients' sense of security and lead to appropriate self-care practices. Vuorinen et al. [19] introduced a system that allows nurses to call directly in the event of anomalies, providing more attentive support. Compared with traditional face-to-face, one-way group patient education, digital technology enables personalized health education, continuous access to health information, and rapid communication with healthcare professionals [33]. These factors suggest that combining digital technology with opportunities for communication with healthcare providers may support self-care. Reminder functions were included in several smartphone-based interventions and were used to prompt medication use, self-monitoring, and attendance at scheduled medical appointments. Several studies that incorporated reminder functions reported improvements in medication-related self-care behaviors [16, 24, 29, 30]. These functions may have supported the performance and continuation of recommended self-care behaviors by reducing missed medications and prompting patients at appropriate times. However, because reminder functions were generally combined with other components, including education, self-monitoring, feedback, and support from healthcare professionals, their independent contribution to the reported outcomes could not be determined.

In addition, mechanisms that provide psychological support and encourage behavioral changes may support self-care. Vital signs were graphed and functioned as graphic feedback; sunflowers were displayed on the screen when goals were achieved [21, 22], and a game function was implemented to provide knowledge about the disease in a quiz format [23]. Such gamification elements are expected to help patients stay motivated and continue their self-care [22]. Further, psychological support incorporating elements of cognitive behavioral therapy and mindfulness was provided [25]. Clays et al. [25] described the intervention as providing a "safe" environment in which patients could learn about their illness and engage with psychological support. This suggests that smartphone-based interventions may serve not only as tools for delivering information, but also as psychologically supportive environments that facilitate engagement with self-care. However, because this component was delivered as part of a multicomponent intervention, its independent contribution to self-care outcomes could not be determined. In Jiang et al. [30, 31], interventions delivered by professionals trained in motivational interviewing were used to reduce patient anxiety and improve self-management skills; the authors reported that motivational interviewing techniques supported self-efficacy by encouraging reflection on past successes and promoting positive self-talk. Therefore, integrating psychological support with mechanisms that promote behavioral change may be important for supporting self-care.

Enhanced collaboration with healthcare providers is another important characteristic of smartphone-based interventions and has been associated with better self-care maintenance and management. In particular, the smooth sharing of information through the app will enable healthcare providers to properly assess the patient's condition and provide necessary guidance at the right time. Enhanced remote monitoring and AI-based risk prediction could also improve the quality of future interventions. For example, real-time collection and analysis of biometric data, such as heart rate, weight, and blood pressure, using wearable devices and smartphone applications, have shown potential for early detection of acute heart failure exacerbations [24]. Such technology, combined with AI-based predictive models, is expected to estimate the risk of rehospitalization and optimize the timing of nurse intervention.

However, the integration of AI and wearable devices into heart failure self-care support also presents important limitations. First, the reliability of AI-generated predictions depends on the quality and completeness of the input data. Sensor inaccuracy, device malfunction, missing data, inconsistent device use, and errors in patient-entered information may reduce the accuracy of risk estimates and lead to inappropriate alerts or missed clinical deterioration. Second, ethical concerns include limited transparency regarding how algorithms generate predictions, the possibility of bias arising from nonrepresentative training data, and the risk of false-positive or false-negative classifications. Therefore, AI-generated information should support rather than replace clinical judgment, and clear procedures are needed for reviewing alerts and responding to uncertain or conflicting results. Third, the continuous collection and

transmission of personal health data raises concerns regarding privacy and security, including data protection, unauthorized access, secondary use of data, and the adequacy of informed consent. Patients should be clearly informed about what data are collected, how they are analyzed and shared, and how long they are retained. Addressing these issues through data-quality monitoring, algorithmic transparency, human oversight, robust security measures, and ongoing consent processes will be essential before these technologies can be implemented safely and equitably in routine heart failure care.

As discussed above, it is important to consider multiple factors in the design of smartphone-based interventions, including motivational mechanisms, personalized support, user-friendly design, and stronger collaboration with healthcare professionals. Future development and implementation of intervention programs that incorporate these factors will be required.

In studies assessing self-care behavior using the EHFScBS, the version of the instrument and the scoring procedures varied. Some studies retained the original scoring direction, in which lower scores indicated better self-care behavior, whereas others used reverse scoring or transformed scores so that higher scores indicated better self-care behavior. These differences may complicate direct comparisons across studies if the version, score range, and scoring direction are not clearly reported. Future studies and reviews should explicitly report the EHFScBS version, scoring range, scoring direction, and any score transformation used to facilitate accurate interpretation and comparison of findings.

Challenges of Smartphone-Based Interventions

This study identified both reported outcomes and implementation challenges associated with smartphone-based interventions for patients with heart failure.

First, technical assistance was essential for the realization of smartphone-based interventions. In addition to initial support such as installing the application, pairing and synchronization with the device, and instructions on how to operate the device, ongoing technical support throughout the study was necessary. This suggests that for a successful smartphone-based intervention, it is important to establish a long-term support system, and not only at the time of implementation. The relatively younger age group, with an average age of 55.4 years, demonstrated higher satisfaction with smartphone applications and Bluetooth-based devices, and a stronger intention to continue using them [24], suggesting that an intuitive, easy-to-use design may influence continued use. However, at a mean age of 70.31 years, some patients did not use the application; nevertheless, with regular record checks by nurses, reminders, feedback, and personalized support through the chat function, the majority of patients completed the study [32]. In addition, participants with a lower economic status and digital literacy struggled with the app and had to create an instruction manual to learn the operating procedures; however, over 60 % of the data were successfully collected [17]. This indicates that a certain level of data collection is possible even for subjects with low digital literacy, such as the elderly. It is important to create an environment where users feel comfortable using digital devices by establishing a cooperative system that utilizes family support and local resources, designing user interfaces that emphasize voice operation, simple interfaces, and intuitive operability, as well as providing face-to-face support at the time of initial installation, and creating video and voice guidance in operation manuals. It is important to create an environment in which users can confidently use digital devices. By combining these multifaceted support measures, it will be necessary to improve ease of use and strengthen the support system so that it can be applied to patients across more diverse age groups and with varying levels of digital literacy.

Additional obstacles to implementation include concerns about personal information protection and the unevenness of the Internet environment. In some cases, especially in remote areas or among elderly households, a stable communication environment may not be available, and delays in data transmission or poor connections may become an issue. In addition, the burden on healthcare providers cannot be underestimated. Human resources and work systems must be in place to continuously check data collected from applications and remote monitoring and take appropriate action. There are concerns that this will increase the existing workload.

In the future, it will be necessary to improve operational simplicity and strengthen the support system so that the system can be applied to a broader range of age groups and patients with varying levels of digital literacy.

Considering the above, it is essential to establish a comprehensive support system that combines technical and human support to facilitate the broader implementation of smartphone-based interventions. Moreover, improving the apps' usability, implementing measures to adapt them for a population unfamiliar with digital devices, and establishing a sustainable operational system in clinical settings will enable more patients to benefit from this technology.

LIMITATIONS

This review had several limitations. First, the intervention programs combined multiple components, including smartphone applications, educational content, self-monitoring, reminders, feedback, and communication with healthcare professionals, and their structures varied across studies, making it difficult to determine which components were most closely associated with reported self-care outcomes. In addition, the characteristics of patients with heart failure

varied across studies, and factors such as age, comorbidities, disease severity, digital literacy, and social support may have influenced the reported outcomes. Second, the versions and scoring procedures of the self-care instruments differed across studies. In particular, studies using the EHFScBS differed in the number of items, scoring direction, and use of transformed scores. Although the score range and scoring direction used in each study were clarified in this review, these differences limited direct comparison across studies. Furthermore, follow-up periods were relatively short, and the sustainability of long-term self-care outcomes was not fully examined. Third, the eligibility criteria were restricted to studies that assessed self-care using the SCHFI or EHFScBS. Consequently, studies evaluating other clinically relevant outcomes, such as medication adherence, symptom monitoring, self-efficacy, quality of life, heart failure knowledge, hospitalization, or healthcare utilization, were not included unless they also used one of these two instruments. Therefore, the findings do not represent the entire body of evidence on smartphone-based interventions related to heart failure self-care. Fourth, the search strategy was intentionally designed to identify studies focusing on smartphone-based interventions supporting self-care in patients with heart failure. Consequently, studies indexed using broader digital health–related terminology may not have been identified. Fifth, this review aimed to provide a comprehensive overview of the existing literature and did not systematically assess the risk of bias or certainty of evidence. Therefore, the findings should be interpreted with caution. In addition, although this review discussed the potential future integration of AI and wearable devices, the included studies provided limited evidence regarding data quality, algorithmic transparency and bias, false-positive or false-negative alerts, privacy and security, and informed consent. Therefore, the clinical feasibility and safety of these technologies could not be fully evaluated. Finally, the included studies reflected different conceptualizations of self-care. In particular, the SCHFI conceptualizes self-care as a naturalistic decision-making process encompassing self-care maintenance, symptom perception, and self-care management, whereas the EHFScBS measures self-care primarily as adherence to recommended self-care behaviors. These differences in conceptual frameworks may have contributed to heterogeneity in the reported outcomes and limit the comparability of findings across studies.

CONCLUSION

This scoping review mapped smartphone-based interventions for patients with heart failure in studies that assessed self-care using the SCHFI or EHFScBS. A complex intervention utilizing a smartphone application may support self-care in patients with heart failure. Across the included studies, commonly reported intervention characteristics included personalized support, motivational mechanisms, an easy-to-use design, and enhanced collaboration with healthcare providers. However, because this review was restricted to studies using the SCHFI or EHFScBS, the findings do not represent all smartphone-based interventions addressing other outcomes related to heart failure self-care. Future research should examine long-term outcomes and clarify how intervention components influence self-care measured using standardized heart failure–specific instruments. Further investigation of integration with AI and wearable devices may also contribute to more advanced and personalized self-care support, provided that issues related to data quality, safety, ethics, privacy, security, and data governance are adequately addressed. In addition, it is important to develop multifaceted support measures for older adults and people with low digital literacy, including support from family members; collaborative systems that utilize local resources; voice-operated and simple, intuitive interfaces; face-to-face support during initial implementation; and video- and audio-based operational guidance. Combining these support measures may improve the accessibility and applicability of digital interventions for a broader range of patients and inform the further development of smartphone-supported self-care for heart failure.

AUTHOR CONTRIBUTIONS STATEMENT

Hiroko Yamamoto: Conceptualization, Methodology, Formal analysis, Investigation, Writing–Original Draft, Visualization. Itoko Tobita: Supervision, Project administration, Formal analysis, Investigation, Writing–review and editing.

DECLARATION OF CONFLICTING INTERESTS

The authors declare no conflicts of interest associated with this manuscript.

FUNDING

This study was supported by a Graduate Student Research Grant from the Graduate School of Nursing, Osaka Medical and Pharmaceutical University. The funder had no role in the study design, data collection, analysis, interpretation of the data, writing of the report, or the decision to submit the paper for publication.

REFERENCES

1. Johnson C, Roth GA. Global aetiologies of heart failure: results from the Global Burden of Disease Study 2023. *Eur Heart J.* 2025;46(Suppl 1):ehaf784.1065. doi: 10.1093/eurheartj/ehaf784.1065
2. Heidenreich PA, Bozkurt B, Aguilar D, et al.

2022AHA/ACC/HFSA guideline for the management of heart failure. *J Am Coll Cardiol.* 2022;79(17). doi: 10.1016/j.jacc.2021.12.012
3. Bowers MT, Carter T. Heart failure: priorities for transition to home. *Nurs Clin North Am.* 2023;58(3):283–294. doi: 10.1016/j.cnur.2023.05.001
4. Riegel B, Dickson VV, Faulkner KM. The situation-specific theory of heart failure self-care: revised and updated. *J Cardiovasc Nurs.* 2016;31(3):226–235. doi: 10.1097/JCN.0000000000000244
5. Rizzuto N, Charles G, Knobf MT. Decreasing 30-day readmission rates in patients with heart failure. *Crit Care Nurse.* 2022;42(4):13–19. doi: 10.4037/ccn2022417
6. Wohlfahrt P, Jenča D, Stehlik J, et al. Heart failure-related quality-of-life impairment after myocardial infarction. *Clin Res Cardiol.* 2023;112(1):39–48. doi: 10.1007/s00392-022-02008-z
7. Mahalwar G, Kumar A, Kalra A. Virtual cardiology: past, present, future directions, and considerations. *Curr Cardiovasc Risk Rep.* 2023;17(6):117–122. doi: 10.1007/s12170-023-00719-0
8. Leigh JW, Gerber BS, Gans CP, Kansal MM, Kitsiou S. Smartphone ownership and interest in mobile health technologies for self-care among patients with chronic heart failure: cross-sectional survey study. *JMIR Cardio.* 2022;6(1):e31982. doi: 10.2196/31982
9. GSMA. The State of Mobile Internet Connectivity Report 2024. London, UK: GSMA; 2024. https://www.gsma.com/solutions-and-impact/connectivity-for-good/mobile-for-development/gsma_events/the-state-of-mobile-internet-connectivity-report-2024/. Accessed June 4, 2026.
10. Ministry of Internal Affairs and Communications. Results of the 2023 Survey on Telecommunications Usage Trends. https: //www.soumu.go.jp/johotsusintokei/statistics/statistics05a.html. Accessed June 4, 2026.
11. Tricco AC, Lillie E, Zarin W, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med.* 2018;169(7):467–473. doi: 10.7326/M18-0850
12. Riegel B, Lee CS, Dickson VV, Carlson B. An update on the self-care of heart failure index. *J Cardiovasc Nurs.* 2009;24(6):485–497. doi: 10.1097/JCN.0b013e3181b4baa0
13. Jaarsma T, Strömberg A, Mårtensson J, Dracup K. Development and testing of the European Heart Failure Self-Care Behaviour Scale. *Eur J Heart Fail.* 2003;5(3):363–370. doi: 10.1016/S1388-9842(02)00253-2
14. Chen Y, Lu M, Jia L. Psychometric properties of self-reported measures of self-management for chronic heart failure patients: a systematic review. *Eur J Cardiovasc Nurs.* 2023;22(8):758–764. doi: 10.1093/eurjcn/zvad028
15. Riegel B, Barbaranelli C, Carlson B, et al. Psychometric testing of the revised self-care of heart failure index. *J Cardiovasc Nurs.* 2019;34(2):183–192. doi: 10.1097/JCN.0000000000000543
16. Seto E, Leonard KJ, Cafazzo JA, Barnsley J, Masino C, Ross HJ. Mobile phone-based telemonitoring for heart failure management: a randomized controlled trial. *J Med Internet Res.* 2012;14(1). doi: 10.2196/jmir.1909
17. Heiney SP, Donevant SB, Arp Adams S, Parker PD, Chen H, Levkoff S. A smartphone app for self-management of heart failure in older African Americans: feasibility and usability study. *JMIR Aging.* 2020;3(1). doi: 10.2196/17142
18. Kiyarosta N, Najafi Ghezeljeh T, Naghashzadeh F, Feizi M, Haghani S. The effect of using smartphone applications on self-care in patients with heart failure. *Nurs Pract Today.* 2020;7(4):305–313. doi: 10.18502/npt.v7i4.4041
19. Vuorinen AL, Leppänen J, Kaijanranta H, et al. Use of home telemonitoring to support multidisciplinary care of heart failure patients in Finland: randomized controlled trial. *J Med Internet Res.* 2014;16(12). doi: 10.2196/jmir.3651
20. Ware P, Shah A, Ross HJ, et al. Challenges of telemonitoring programs for complex chronic conditions: randomized controlled trial with an embedded qualitative study. *J Med Internet Res.* 2022;24(1). doi: 10.2196/31754
21. Son YJ, Choi J, Kim HM, et al. Development and evaluation of a patient-family caregiver dyad mHealth intervention for heart failure self-care: a quasi-experimental study. *J Med Internet Res.* 2025;27. doi: 10.2196/74922
22. Son YJ, Kim EY. The effectiveness and usability of a novel mobile phone-based self-care intervention for patients with heart failure: a mixed-methods pilot study. *Eur J Cardiovasc Nurs.* 2023;22(3):254–263. doi: 10.1093/eurjcn/zvac077
23. Bakogiannis C, Tsarouchas A, Mouselimis D, et al. A patient-oriented app (ThessHF) to improve self-care quality in heart failure: from evidence-based design to pilot study. *JMIR Mhealth Uhealth.* 2021;9(4). doi: 10.2196/24271
24. Kitsiou S, Gerber BS, Buchholz SW, Kansal MM, Sun J, Pressler SJ. Patient-centered mHealth intervention to improve self-care in patients with chronic heart failure: phase 1 randomized controlled trial. *J Med Internet Res.* 2025;27. doi: 10.2196/55586
25. Clays E, Puddu PE, Luštrek M, et al. Proof-of-concept trial results of the HeartMan mobile personal health system for self-management in congestive heart fail-

ure. *Sci Rep.* 2021;11:5663. doi: 10.1038/s41598-021-84920-4
26. Reif S, Schubert S, Stiefel J, et al. Supporting patients with heart failure with digital therapeutics—a pilot study in Germany. *Digit Health.* 2022;8:20552076221143899. doi: 10.1177/20552076221143899
27. Dorsch MP, Farris KB, Rowell BE, Hummel SL, Koelling TM. The effects of the ManageHF4Life mobile app on patients with chronic heart failure: randomized controlled trial. *JMIR Mhealth Uhealth.* 2021;9(12). doi: 10.2196/26185
28. Son YJ, Kim SW, Lee WS, et al. The effects of a 24-week interactive text message-based mobile health intervention for enhancing self-care behaviours of patients with heart failure: a quasi-experimental study. *Nurs Open.* 2023;10(9):6309–6319. doi: 10.1002/nop2.1878
29. Athilingam P, Jenkins B, Johansson M, Labrador M. A mobile health intervention to improve self-care in patients with heart failure: pilot randomized control trial. *JMIR Cardio.* 2017;1(2). doi: 10.2196/cardio.7848
30. Jiang Y, Koh KWL, Ramachandran HJ, et al. The effectiveness of a nurse-led home-based heart failure self-management programme (the HOM-HEMP) for patients with chronic heart failure: a three-arm stratified randomized controlled trial. *Int J Nurs Stud.* 2021;122:104026. doi: 10.1016/j.ijnurstu.2021.104026
31. Jiang Y, Shorey S, Nguyen HD, et al. The development and pilot study of a nurse-led HOMe-based HEart failure self-management programme (the HOM-HEMP) for patients with chronic heart failure, following Medical Research Council guidelines. *Eur J Cardiovasc Nurs.* 2020;19(3):212–222. doi: 10.1177/1474515119872853
32. Choi EY, Park JS, Min D, Ahn S, Ahn JA. Heart failure-smart life: a randomized controlled trial of a mobile app for self-management in patients with heart failure. *BMC Cardiovasc Disord.* 2023;23:7. doi: 10.1186/s12872-023-03039-8
33. Doswell WM, Braxter B, DeVito Dabbs A, Nilsen W, Klem ML. mHealth: technology for nursing practice, education, and research. *J Nurs Educ Pract.* 2013;3(10):99–109. doi: 10.5430/jnep.v3n10p99

Received June 25, 2026
Accepted September 2, 2026

Supporting Information for this article is available in our online journal.
Official Website https://ompu.repo.nii.ac.jp/search?search_type=2&q=83
J-STAGE https://www.jstage.jst.go.jp/browse/bullompu/list/-char/ja

© 2026 The Editorial Board of Bulletin of Osaka Medical and Pharmaceutical University

https://creativecommons.org/licenses/by-nc-sa/4.0/