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Scoping Review
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Mobile Health Assisted Self Monitoring in Heart Failure Patients To Ensure Quality of Life: A Scoping Review

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ABSTRACT

Background: Heart failure leads to reduced quality of life, high hospitalization rates, mortality rates, and treatment costs where out-of-hospital self-monitoring can help with management and prevention of hospitalization and digital apps can help with this. The purpose of this review was getting all information of the studies regarding self-monitoring assisted by mobile health or digital application for heart failure patients.

Subjects and Method: Using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols for a Scoping Review (PRISMA-ScR), literature searches were developed by searching the databases: PubMed.gov, ScienceDirect, SpringerLink, Google Scholar. Following the eligibility criteria, articles that included were analyzed to get the result.

Results: Mostly the studies were conducted in 2016 and 2017 (20% each, n=5), less studies in 2018, 2019, 2020, and increased again in 2021 (16%, n=4). The studies were done 57% in USA (n=13), both Australia and Canada were 9% (n=2), and other countries. The designs of the studies were mostly RCT (74%, n=17). Sample size was variative mostly less than 50 participants (39%, n=9). There were 65% of the studies measured the daily body weight (n=15), others used vital signs 57%, medication adherence 39%, and other items. QoL was the most in the outcome (61%, n=14). Main findings mostly showed positive impact on self-monitoring with digital application.

Conclusion: Using mobile apps for heart failure patients' self-monitoring created the positive impacts in the expected outcomes, mostly for quality of life.

Keywords: self-monitoring, heart failure, mobile health, quality of life

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BACKGROUND

Text As a complex clinical syndrome, heart failure shows any structural or functional impairment of ventricular filling or ejection of blood (Yancy et al., 2013). The increased prevalence, the escalated healthcare costs, the repeated hospitalizations, the reduced QoL and the early mortality have transformed this disease to an epidemic worldwide (Son et al., 2012). It is estimated that 38 million people worldwide have heart failure, with most published studies reporting a prevalence of between 1% and 2% of the adult population. In Europe and North

America, 1%–2% of all hospital admissions are related to heart failure and more than 1 million admissions annually, 80–90% with decompensation of chronic heart failure. It still carries a poor prognosis: 5% to 10% of patients die during hospitalization, 15% dying by 3 months, and over half of patients die within 5 years of their first heart failure hospitalization. Rates of rehospitalization are also high. The financial burden of heart failure, principally due to the cost of hospitalization, is expected to increase substantially in the coming decades due to the aging of the population (Reyes et al., 2016). In the United States, heart failure incidence increases with age, rising from approximately 20 per 1,000 individuals 65 to 69 years of age to >80 per 1,000 individuals among those 85 years of age. Approximately 5.1 million persons in the United States have clinically manifest heart failure, and the prevalence continues to rise (Yancy et al., 2013). Other estimates indicate that the prevalence of heart failure in the United States and Canada is 1.5% to 1.9% of the population and in Europe 1% to 2% (Roger, Weston and Redfield, 2004). The estimated absolute number of prevalent heart failure cases in the UK increased even more, by 23% (Conrad et al., 2018).

Among patients with heart failure, hospitalizations were common after heart failure diagnosis, with 83% of patients hospitalized at least once and 43% hospitalized at least 4 times (Yancy et al., 2013). Although survival has improved, the absolute mortality rates for heart failure remain approximately 50% within 5 years of diagnosis, 7% of all cardiovascular deaths (Yancy et al., 2013). The cost of managing heart failure in the early 1990s was estimated to be 1–2% of total health care expenditure in US (McMurray and Stewart, 2000).

In Asia, the prevalence of heart failure (1% to 3%) and 5% were reported from Indonesia and Taiwan. Taiwan had highest hospitalizations annually (40.000). Rates of readmission ranged between 3% and 15% at 30 days. The length of stay in hospital was between 5 days (Indonesia) and 12.5 days (Taiwan). The rate of in-hospital mortality was also similar to values reported in Europe and the USA. Mortality rate at 30 days was varied from 1% (Malaysia) to 17% (Indonesia).

Global Burden of Diseases study showed transition of the causes of DALYs (Disability Adjusted Live years) from 1990 to 2016 in Indonesia. In 1990 the main causes were the communicable, maternal, neonatal, and nutritional diseases (CMNN) lead by diarrheal diseases, in 2006 ischemic heart disease became the first cause followed by cerebrovascular diseases on the third which became the first and the second causes in 2016. Between 1990 and 2016, life expectancy at birth in Indonesia increased by 8 years with an increase in the prevalence of heart and cerebrovascular disease that Heart failure has an impact on high rates of hospitalization, morbidity, mortality, costs and decreased QoL, especially in the areas of physical function and vitality. Self-care that is continuously monitored by a doctor is important to maintain a stable condition at home to reduce readmission and improve QoL. Patients need guidance and reminders to help them participate in their own health on a consistent basis.

Digital transformation has developed very rapidly in various aspects of human life that can be used for innovative patient-centered interventions to improve self-management that is complex, expensive and easy to relapse and become acute such as heart failure. Mobile apps like mHealth are expected to help. Patients who still require continuous treatment will be monitored and supported by the clinicians or health center providing the treatment.

This review covers the use of digital systems in heart failure patients, focusing on self-monitoring, telemonitoring, and mobile health, looking at how these technologies can be used to support treatment and improve outcomes can cause heart failure (Mboi et al., 2018).

SUBJECTS AND METHOD

1. Study design and search strategy

Using qualitative and quantitative study design, we conducted a scoping review on self-digital monitoring for heart failure patients. The protocol was drafted utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols for a Scoping Review (PRISMA-ScR) (Tricco et al., 2018). The sequential process included identifying the research question, selecting relevant studies, data charting, and comprehensively summarizing results. Literature searches were developed by searching the databases in PubMed, ScienceDirect, SpringerLink, and Google Scholar. Relevant articles were identified using keywords and index terms and the Boolean logic technique of the retrieved articles.

The articles were searched using-keywords and controlled vocabulary terms, including combinations of terms for self-digital monitoring for heart failure. For PubMed the search started using MeSH terms and the Boolean technic. All data bases were filtered by the range of time from 2012 to 2021 (10 years). The filters added in PubMed search results were the article type: observational study and randomized control trial, species: human, and language: English. For ScienceDirect the additional filter applied was research article. For SpringerLink the filters added were content type: articles and language: English. Specific articles were retrieved to be analyzed and review.

2. Inclusion and exclusion criteria

As the inclusion criteria, this study collected the articles from four databases stated before, in the range of 2012 to 2021 and in English. Selected population is heart failure patients who are given a self-monitoring program with the help of mHealth via mobile phone. We chose randomized control trial, observational or survey studies and in free full text. We exclude studies of other languages, other diseases, animals, other artificial intelligence or technology and case reports or review articles as well as paid articles.

3. Definition of operational variables

Variables definition in this research was based on PICO (Population, Intervention, Comparison and Outcome) framework. For "Population" we chose adult heart failure in all types, "Intervention" was searched by the terms of telemedicine, mobile health, mHealth, telehealth, eHealth, no spesific criteria for "Comparison" and we used prediction or detection for "Outcome".

4. Study instrument

The protocol was drafted utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols for a Scoping Review (PRISMA-ScR) (Tricco et al., 2018).

5. Data analysis

Data charting process

We developed the data charting to determine which variables to extract. By selecting the articles that has been chosen, eliminate the duplicate articles, screening the title and abstract and follow the eligibility criteria including free full text to exclude the unmatched ones, and get the final articles to be studied. Reviewer evaluated each study based on its title, time, location (country), study design/ method, research period, concept, sample size, items monitored, media/ equipment, outcome measured, and main finding.

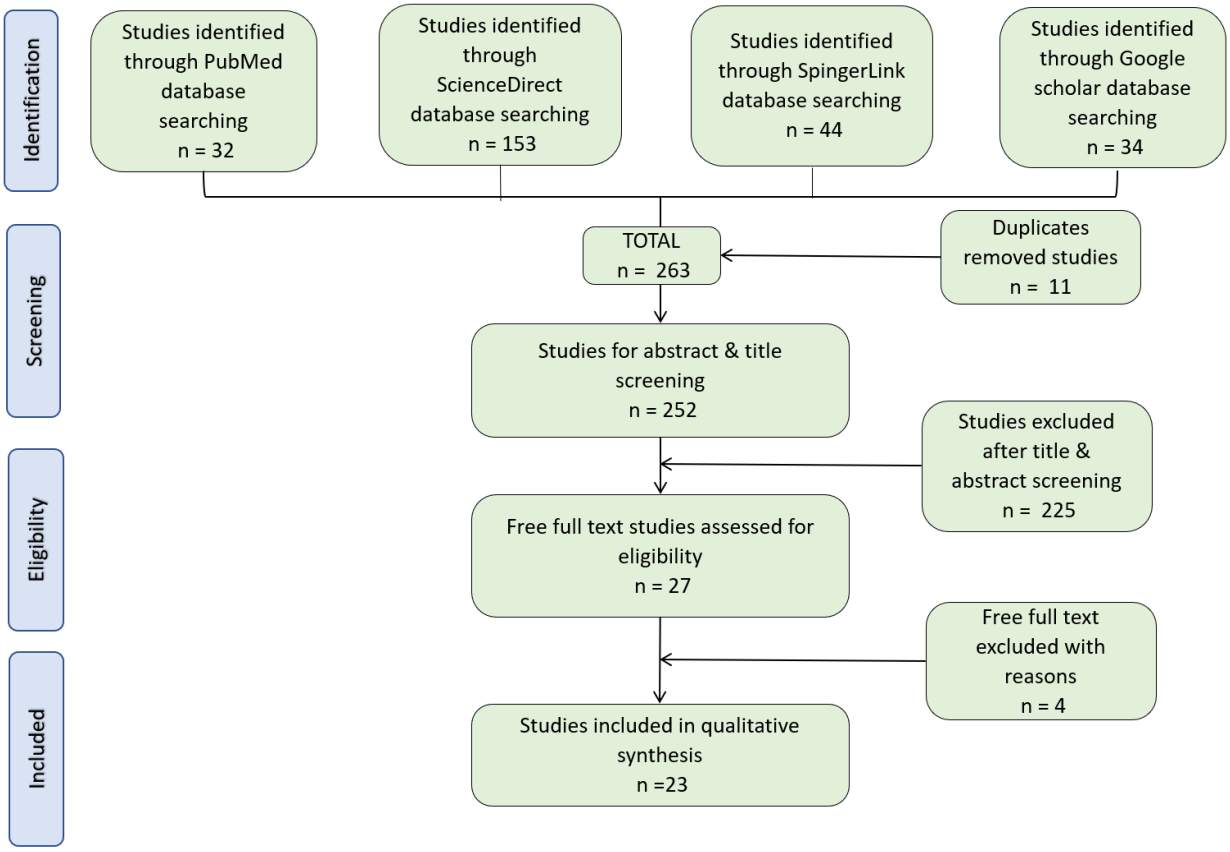

Figure 1. Flowchart of literature search for scoping review on self monitoring with digital application for heart failure patients

RESULTS

1. Selection of sources of evidence

From the databases there were 263 articles retrieved, after removing the duplicates, 252 are proceed to title and abstract screening and remained 27. After filtering with free full text and removed the articles that not matched with the eligibility criteria, 23 articles were included in this review. The flowchart is presented in Fig. 1.

2. Characteristics of sources of evidence (studies).

The 23 included studies are listed in Table 1, with the columns defined:

1. Author
2. Year
3. Location
4. Study Design/method
5. Sample size
6. Items monitored
7. Application name
8. Outcome measured
9. Main findings

Table 1. Summary of the studies

No	Author	Year	Location	Study design/ method	Sample size	Items Monitored	Application Name	Outcome measured	Main Findings
1	(Cartledge *et al.*, 2020)	2020	Melbourne, Australia	Observational pilot study, 30 days each	29 >18 y	Objective measures: BP, Heart Rate, Weight, B-type natriuretic peptide. Subjective measures: symptoms of dyspnea, orthopnea, bendopnea, and paroxysmal nocturnal dyspnea (PND), scored for severity on a 5-point Likert scale	Not specified	Hospital-ization	The use of subjective respiratory symptom reporting on a 5-point Likert scale may facilitate a simple and low-cost method of predicting heart failure decompensation and imminent hospitalization
2	(Evans *et al.*, 2016)	2016	Florida, USA	Observational study, 6 months each	41, ≥ 55 y, 21 HF + 20 non-HF	Skin temperature, motion data, BP, body weight	Not specified	Device usability adherence	A health monitoring system designed for older adults can and will be used for an extended period of time and may help older adults with chronic conditions reside longer in their own homes in partnership with the healthcare system.
3	(Portz *et al.*, 2018)	2018	Colorado & Ohio, USA	Survey	30, >60 y	Weight, fatigue, edema, shortness of breath, cough, stomach bloat, feeling sad, and feeling anxious	HF app	HF app acceptability	The HF app is an acceptable tool for older patients with HF to self-manage their symptoms, identify patterns, and changes in symptoms, and ultimately prevent HF readmission.
4	(Krumholz *et al.*, 2016)	2016	USA, 33 sites	cohort study	1004	Candidate risk factors included 110 variables divided into 2 groups: demographic and clinical variables generally available from the medical record; and	Telemonitoring to Improve Heart Failure Outcomes (Tele-HF)	QoL, hospital readmission for any cause within 30 days after the interview.	Non-Clinical Factors: Self-reported socioeconomic, health status, adherence, and psychosocial variables are not dominant factors in predicting

No	Author	Year	Location	Study design/ method	Sample size	Items Monitored	Application Name	Outcome measured	Main Findings
						socioeconomic, health status, adherence, and psychosocial variables from patient interview.			readmission risk for patients with heart failure. Patient-reported information improved model discrimination and extended the predicted ranges of readmission rates, but the model performance remained poor.
5	(Jiang *et al.*, 2021)	2021	Singapore, a tertiary hospital	three-arm stratified randomized controlled trial	213	Vital signs	HOM-HEMP	QoL, Self-care adherence	HOM-HEMP is an effective intervention for patients with heart failure in Singapore
6	(Gallagher *et al.*, 2017)	2017	NY, USA	RCT	40, 1:1, ≥ 21 y	Medication adherence	TEAM-HF	Adherence to loop diuretics in the 30 days after discharge, 30-day all-cause read-mission and attendance at follow-up clinic appointments	Adherence telemonitoring was acceptable to most patients with HF. Diuretic nonadherence was common even when patients knew they were being monitored
7	(Seto, Leonard, Cafazzo, … J. B.-J. of M., *et al.*, 2012)	2012	Canada	RCT	22, ≥18 y	Daily weight and blood pressure readings, weekly single-lead ECGs, and to answer daily symptom questions	Telemonitoring to Improve Heart Failure Outcomes (Tele-HF)	Self-care adherence, Patients and clinicians perceptions and experiences	The success of a telemonitoring system is highly dependent on its features and design.
8	(Pekmezaris *et al.*, 2019)	2019	USA	RCT	104	Blood pressure, oxygen saturation rate, weight, and pulse/heart rate	Not specified	Emergency department (ED) visits, hospitalizatio	These findings suggest that TSM is not effective in reducing utilization or

No	Author	Year	Location	Study design/ method	Sample size	Items Monitored	Application Name	Outcome measured	Main Findings
								ns, QoL	improving QoL for underserved patients with HF
9	(Steventon *et al.*, 2017)	2017	USA, 33 cardiology practices	RCT	707	Body weight	Telemonitoring to Improve Heart Failure Outcomes (Tele-HF)	Fraud detection	EDP patients were more likely to trigger alerts than NEDPs, regardless of alerting algorithm. As well as overshadowing clinically meaningful changes in weight, end-digit preference can lead to false alerts to telemonitoring systems, which may be associated with unnecessary treatment and alert fatigue
10	(Piette *et al.*, 2015)	2015	USA	RCT	331	Shortness of breath, medication adherence, salt, and fluid intake, and increases in weight	mHealth, Not specified	QoL, Self-care adherence, medication adherence	A model including automated feedback to an informal caregiver outside the household improved HF patients' medication adherence and caregiver communication.
11	(Comín-Colet *et al.*, 2016)	2016	Barcelona, Spain	RCT	178, ≥18 y	Body weight, heart rate and blood pressure, symptoms reporting, generation and management of warning alarms and alerts.	The Home Tele-HealthCare (THC) Platform	QoL, non-fatal heart failure event, mortality, readmission, cost calculation	Among patients managed in the setting of a comprehensive HF program, the addition of telemedicine may result in better outcomes and reduction of costs.
12	(Hale *et al.*, 2016)	2016	USA	randomized controlled pilot study	29	Medication adherence	MedSentry	QoL, medication adherence, health status, EDC Visits & hospital-	The MedSentry medication monitoring system is a promising technology that merits continued development and

No	Author	Year	Location	Study design/ method	Sample size	Items Monitored	Application Name	Outcome measured	Main Findings
								ization, usefulness & satisfaction	evaluation.
13	(Dang *et al.*, 2017)	2017	Miami, USA	RCT	42	weight & symptoms (yes or no)	Not specified	Clinical and sociodemographic characteristics, Usability survey, Program evaluation experiences, perceptions, motivating factors, ability to pay monthly mobile monitoring system	A mobile phone-based disease management program is feasible in a minority county hospital population and offers a modality to help reduce ethnic disparity mobile phone monitoring system is feasible in a predominantly low income, less educated multiethnic population, and most usability challenges may be averted with proper planning and training.
14	(Bohanec *et al.*, 2021)	2021	Belgium 3 hospitals, Italy 1 hospital.	RCT	56	Physical (such as weight, blood pressure, heart rate) and psychological profile (such as moti- vated, anxious, depressed), patient activity, environment (temperature & humidity)	HeartMan DSS	QoL, Self-care management, perception	The results confirmed that the system was successful in improving self-care behavior, decreased patients' levels of depression and anxiety, and improved the overall predicted 1-year mortality risk
15	(Pezel *et al.*, 2021)	2021	France	Cohort study	2517, ≥18 y	not specified	Not specified	QoL, Epidemiological characteristic	Smartphone applications are used by one-third of patients with HF in France, and the number of patients with a smart- phone is increasing exponentially in France and worldwide. mHealth is

No	Author	Year	Location	Study design/ method	Sample size	Items Monitored	Application Name	Outcome measured	Main Findings
									an opportunity to complete existing care.
16	(Athilinga m *et al.*, 2016)	2016	USA	Descriptive survey	37	Weight, BP, vital signs, HF symptoms, exercise	HeartMapp	HeartMapp usability & acceptability	Having access to CHF symptom monitoring and education readily available in a mobile app may motivate individuals to engage in the prescribed self-management skills to ultimately attain desired outcome
17	(Buck *et al.*, 2017)	2017	USA	RCT & Qualitative	12	Not specified	Penn State Heart Assistant (PSHA)	Self-efficacy	Suggestions e conti-nuing use after the stu-dy, technical problems, participant suggested improvements.
18	(Sharma *et al.*, 2019)	2019	USA	RCT	200, ≥18 y, 1;1	Physical activity, medication adherence	mHealth	QoL and improve medication adherence	Using mobile health technologies repre-sents an attractive option to improve health behaviors and outcomes given the widespread use of these technologies. The TARGET-HFDM trial aims to evaluate the hypothesis that a mobile health inter-vention can improve measures of physical activity in patients with diabetes and HF.
19	(Kitsiou *et al.*, 2021)	2021	USA	RCT	92, 1:1	Weight, HF symptoms and blood pressure, medication adherence, adherence to low-sodium diet, and engagement in physical activity.	iCardia4HF	QoL, medica-tion adhe-rence, self-care manage-ment, hos-pitalization, Emergency	iCardia4F represents a meaningful advance in promoting and assess-ing HF self-care

No	Author	Year	Location	Study design/ method	Sample size	Items Monitored	Application Name	Outcome measured	Main Findings
								visit	
20	(Kenealy *et al.*, 2015)	2015	New Zealand	RCT & qualitative evaluation	171, ≥16 y	Weight, BP, O2 saturation, blood glucose	Not specified	QoL, Self-care management	QoL, self-efficacy and dis-ease-specific measures did not change significantly, while anxiety and depression both decreased significantly with the intervention. Hospital admissions, days in hospital, emergency department visits, outpatient visits and costs did not differ significantly between the groups.
21	(Seto *et al.*, 2012)	2012	Canada	RCT	100, 1:1	daily weight, blood pressure readings, weekly single-lead ECGs, daily symptom, medication adherence	Not specifed	QoL, Self-care management, medication adherence, mortality	improved QoL through improved self-care and clinical management from a mobile phone-based telemonitoring system. The use of the mobile phone-based system had high adherence and was feasible for patients, including the elderly and those with no experience with mobile phones
22	(Rahimi *et al.*, 2020)	2020	UK	two-armed partially blinded parallel RCT	202, 1:1, adults	weight, BP, HR, medication adherence	SUPPORT-HF 2	medication adherence, QoL (MLHFQ)	Central provision of tailored specialist management in a multi-morbid HF population was feasible.
23	(Ding *et al.*, 2017)	2017	Australia	Multicenter RCT	300	The project nurses provide structured interventions according to three types of alerts: rapid weight fluctu-	ITEC-CHF	QoL, guidelines compliance	Compared with the traditional management of CHF, this program has the potential to dramati-

No	Author	Year	Location	Study design/ method	Sample size	Items Monitored	Application Name	Outcome measured	Main Findings
						ation, slow weight fluctuation and low-risk weight fluctuation.			cally simplify the daily weight monitoring and management, does not require special knowledge or skills.

Final result will be shown on Figure 2 to 7:

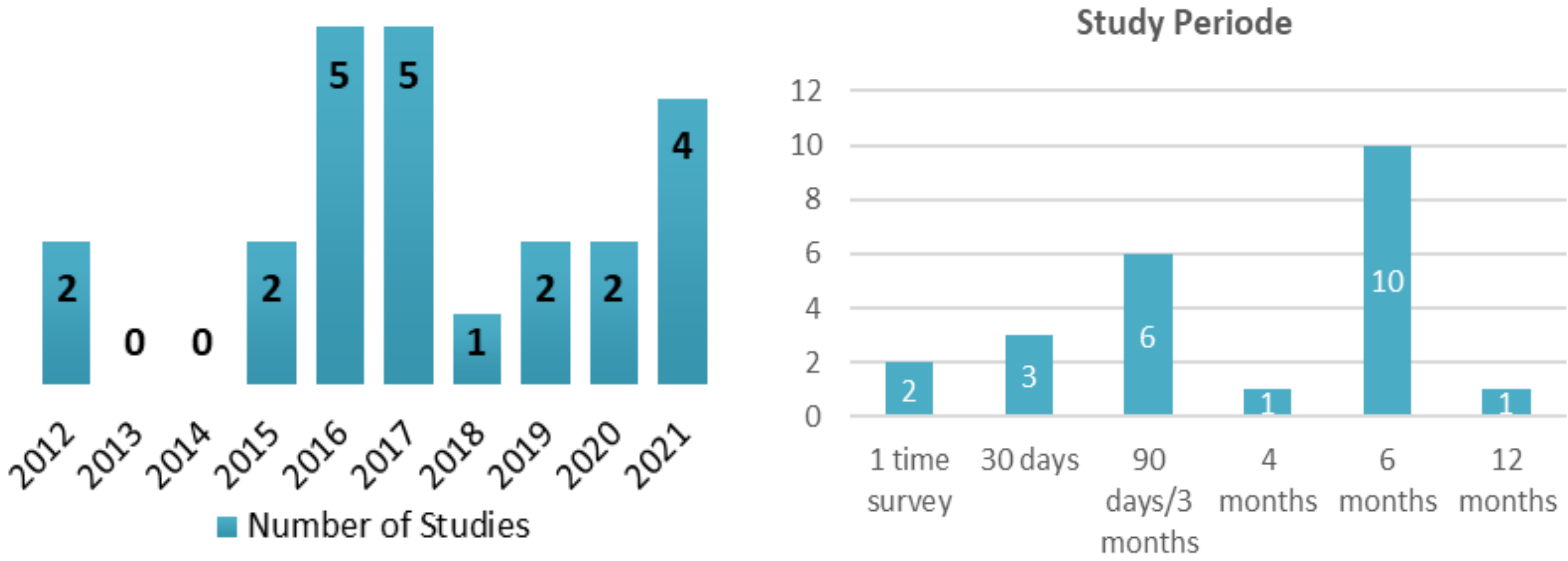

Figure 2. The year and period of the studies.
The studies were conducted mostly in 2016 and 2017 (20% each, n=5), less studies in 2018, 2019, 2020, and increased again in 2021 (16%, n=4). The studies were done in variety length of time and 6 months is the most (40%)

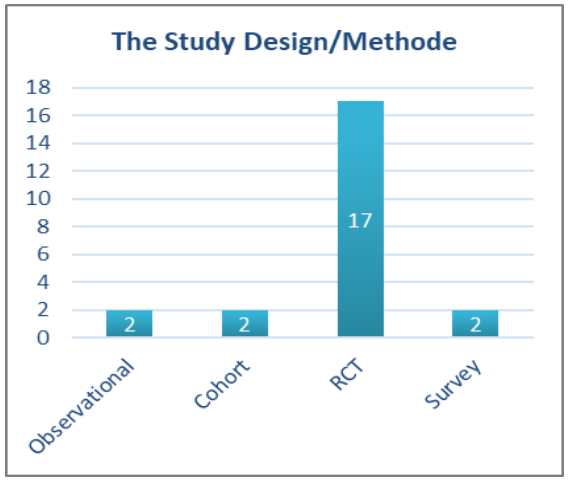

Figure 3. The Study Design/Method.
Most study designs are Randomized Controlled Trial (72%)

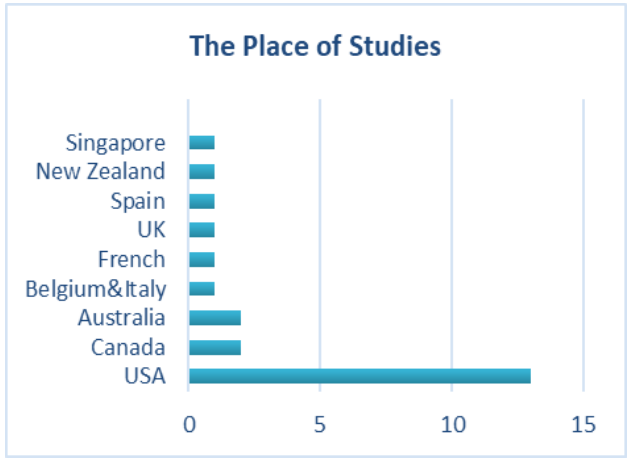

Figure 4. The Country of Studies site.
Mostly the studies were conducted in USA (52%).

Figure 5. The sample size of the studies.
Mostly less than 50 participants

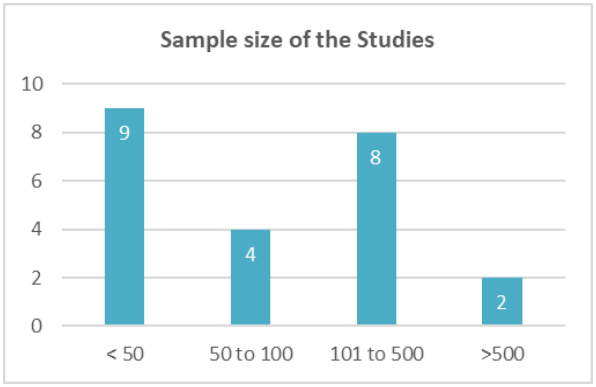

Figure 6. The Item Monitored by The Studies
Body weight is the highest preference to be monitored, followed by vital signs and medication adherence.

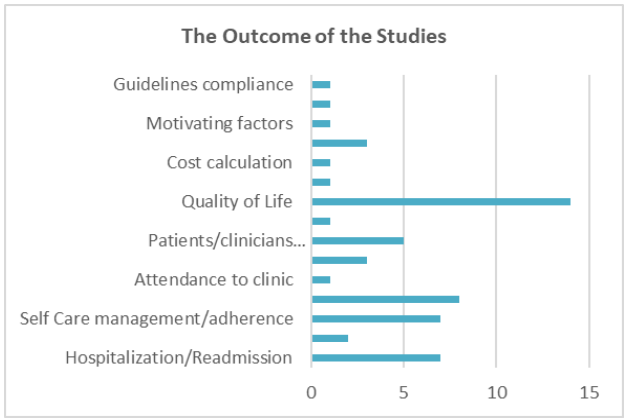

Fig 7. The Outcome measured by the Studies.
QoL is the most, followed by medication adherence, self-care management and hospitalization or readmission

3. Synthesis of Results

Table 1 summarizes the analysis using 11 components. Except the Title, Author and Year specify the author and the year of the study. Location is the country that the study been conducted. The Design is the type or method of study. Research period means the time that has been taken to complete the study. Sample size refers to how many people that been chosen ass a participant. Item measured is the item of measurements done by the patients as self-monitoring with or without specific equipment. Application name is the specific name of the digital media or application that used in the study to assist the patient do the self-monitoring and for the clinician or healthcare provider to get the data or to deliver the communication and transfer the information. Outcome measured is the final achievement of the study. Main findings are the points of the conclusion.

The studies were conducted mostly in 2016 and 2017 (20% each, n=5), less studies in 2018, 2019, 2020, and increased again in 2021 (16%, n=4). The studies were done 57% in USA (n=13), both Australia and Canada were 9% (n=2), and 1 study from both Belgium and Italy (Bohanec et al., 2021), France (Pezel et al., 2021), UK (Rahimi et al., 2020), Spain (Comín-Colet et al., 2016), New Zealand (Kenealy et al., 2015) and Singapore (Jiang et al., 2021). The design or method of the studies mostly RCT (74%, n=17) as the criteria was defined for RCT or observational and survey study.

Sample size was variative from 12 to 2517 participants, mostly less than 50 (39%, n=9). There were 65% of the studies measured the daily body weight (n=15), others used vital signs 57% (Heart rate, blood pressure, body temperature, oxygen saturation), medication adherence 39%, physical and psychological symptoms, and others with non-physical examination measurements such as physical motion or activities, or nutrition or fluid intake, and environment (temperature and humidity). The names of the application are HF App, Tele-HF, HOM-HEMP, TEAM-HF, The Home Tele-Health Care, MedSentry, Heart-ManDSS, HeartMapp, Penn State Heart Assistant, iCardia4HF, ITEC-CHF and some studies had no specific application name.

For the outcome also was variative: QoL (61%, n=14), Medication adherence (35%, n=8), Self-care management/ adherence (30%, n=7), Hospitalization/ readmission (30%, n=7) and others as reported in Fig.8.

Main findings mostly showed positive impact on self-digital monitoring with digital application due to the outcome or aim achievement (QoL, feasibility, usability, acceptability, adherence, hospital/ emergency department visit and readmission prevention). One study showed non-significant impact (Pekmezaris et al., 2019). One study showed that non-clinical risk factors are not dominant factors in predicting readmission risk (Krumholz et al., 2016).

DISCUSSION

The shift of mortality causes has changed from communicable diseases to non-communicable diseases in recent years which is the primary cause is cardiovascular diseases including heart failure (Mboi et al., 2018). The increased prevalence, the escalated healthcare costs, the repeated hospitalizations, the reduced QoL and the early mortality of heart failure patients encourage the additional effort from patient-clinicians engagement. Self-monitoring is done in many ways but still inconsistence due to patient's adherence and lack of communication with clinicians, where a mobile application could help and increase their QoL and reduce readmission rate.

Treatment of chronic diseases, such as heart failure, requires complex protocols based on early diagnosis; self-monitoring of symptoms, vital signs and physical activity; regular medication intake; and education of patients, family and caregivers about relevant aspects of the disease. Smartphones and mobile health applications could be very helpful in improving the efficacy of such protocols, but from the research result, several barriers make it difficult to fully exploit their technological potential and produce clear clinical evidence of their effectiveness (Mortara et al., 2020).

Given the complexity of Heart Failure self-care, assisting patients to manage their own care at home is a key component of Heart Failure management. The studies that included in this review used variety terminologies or focuses on "self-monitoring", apps or wearables and outcomes. They used self-monitoring or self-care that had the meaning of doing the monitor by patient himself or family or caregiver including simple measurements and symptoms with or without equipment or tools, management of health behavior, medication adherence, daily activities and adherence in using the apps.

In accordance with the passage of time, digital technology is increasingly being updated, as well as research being developed in heart failure. The studies about using mHealth or digital application for heart failure self-monitoring program has been started in 2012 (Seto et al., 2012) in a range of this review's time. It means there could be many efforts form scientist, clinicians, or health care providers to get benefit of the technology growth in healthcare. In 2016 and 2017, many researchers did this kind of research, decreased in 2018 and began to be carried out again in the following years, especially in 2021 with the presence of covid 19. And The United States is the country that has done the most of this research, done in several states. Due to the increasing prevalence of heart failure, research is also ongoing worldwide.

The application with various names run by a smartphone or computer tablet belongs to patients or provided by the researcher or the institution. There are many variations in items monitored by patients or clinicians. Some studies also provided specific equipment for patient self-monitoring such as electronic weighing scale, blood pressure monitor, glucometer, pulse oximeter and even an ECG monitor (Seto et al., 2012) were automatically sent wirelessly via Bluetooth to a mobile phone and then to the data repository at the hospital.

The studies were conducted 30 days after a patient was admitted in hospital, or more, mostly in 6 months. The needs of the heart failure patient to be monitored intensively is in 30 days after discharge from hospital for an acute attack of heart failure. There were also studies that being done for one time study (Athilingam et al., 2016; Portz et al., 2018).

QoL is the main outcome that is measured in these studies. They quantify physical and psychological function, symptoms (frequency, severity and recent change), social function, self-efficacy and knowledge. The next outcomes are medication adherence, self-care management adherence, hospitalization/ readmission and patient/ clinician perception/ experiences/ satisfaction. These were the top 5 chosen by researchers and gave results in good impacts. Other outcome also includes the device usability/ acceptability/ adherence, guideline compliance, efficacy, and 1 includes cost calculation.

There were many instruments or questionnaire used by the researcher to measure the outcomes, such as to measure

QoL, self-care management/adherence, self-efficacy, patient acceptance, compliance, including:

- HRQoL; Health Related Quality of Life
- MLHFQ: Minnesota Living with Heart Failure Questionnaire
- SCHFI: Self Care Heart Failure Index
- KCCQ: Kansas City Cardiomyopathy Questionnaire
- HFCQ: Heart Failure Compliance Questionnaire
- HFSCB: Revised Heart Failure Self-care Behavior Scale
- ESCBS: European Self-care Behavior Scale
- TEQ: Technology Experience Questionnaire
- System Usability Scale
- MAGGIC Risk Score
- Self-efficacy of Bandura
- Self-efficacy for Managing Chronic Disease
- EQ-5D: European QoL Five Dimension
- CDS-SF2: Cardiac Depression Scale
- Frailty Scale (Canadian Family Index)
- CSES: Cardiac Efficacy Scale
- SSQ6: Short Form of the Social Support Questionnaire
- Screening Scale for Anxiety & Depression
- Patient Health Questionnaire

The instruments or questionnaire were chosen according to the aim of the studies. Even though the instruments or questionnaire are valid and reliable from previous studies, it's still not a comparison between one another because there is no standardization to use single questionnaire as well as the digital applications. The variety of the application name, the methods, type, support system, devices, features, easiness, convenience can impact technology acceptance and self-care adherence.

Main findings mostly showed positive impact on self-digital monitoring with digital application due to the outcome or aim achievement (QoL, feasibility, usability, acceptability, adherence, hospital/ emergency department visit and readmission prevention). A study that compared utilization and QoL for underserved black and Hispanic heart failure with telehealth self-monitoring showed no- significant impact (Pekmezaris et al., 2019). One study that analyze the risk factors showed that non-clinical risk factors are not dominant factors in predicting readmission risk (Krumholz et al., 2016).

As a conclusion, most articles delivered the message that using digital health system including mobile apps create the positive impacts in the expected outcomes, although there was 1 study showed non-significant impact. This will motivate and encourage many institutions conduct this service in many ways and follow technology updates. Heart failure is found all over the world, but not all countries have conducted research on self-monitoring assisted by digital application like in this review. In the future, this should be a concern to improve comprehensive management, easy, acceptable, convenient and to maintain the QoL of heart failure patients. This review has limitations:

- Only a few databases are used as the source of this review, additional databases could be more useful.
- This review excluded other languages (only English) so this analysis may have excluded relevant information and failed to consider certain contexts.
- The population is patients with heart failure which could be not in the same condition. Some studies used New York Heart Association (NYHA) classification, others just chose the chronic heart failure.

Even though has limitations, this review gives important information that telemonitoring with digital apps is a promising method for supporting both patients and clinicians in the management of Heart Failure.

AUTHORS CONTRIBUTION

F.E.I. designed the research protocol and wrote the first version of the manuscript under the supervision of K.N.S and B.S. All authors carried out the bibliographic search. They all participated in decisions on which studies to include in the review, providing interpretation of results and the writing of the final version of the manuscript. All authors have read and and agreed to the published version of the manuscript.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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