The influence of mobile health on the knowledge and self-management of patients with chronic heart failure

LENS Laura, OOSTERBOS Lauren, VRYSEN Arne (KU Leuven)

Promotor: VAES, Bert (KU Leuven)

Co-promotoren: RAAT Willem, SMEETS Miek (KU Leuven)

Master of Family Medicine

Masterproef Huisartsgeneeskunde
Academiejaar: [2022 – 2023]

Deze masterproef is een examendocument dat niet werd gecorrigeerd voor eventueel vastgestelde fouten. Zonder voorafgaande schriftelijke toestemming van zowel de promotor(en) als de auteur(s) is overnemen, kopiëren, gebruiken of realiseren van deze uitgave of gedeelten ervan verboden. Voor aanvragen tot of informatie i.v.m. het overnemen en/of gebruik en/of realisatie van gedeelten uit deze publicatie, wendt u tot de universiteit waaraan de auteur is ingeschreven.

Voorafgaande schriftelijke toestemming van de promotor(en) is eveneens vereist voor het aanwenden van de in dit afstudeerwerk beschreven (originele) methoden, producten, schakelingen en programma's voor industrieel of commercieel nut en voor de inzending van deze publicatie ter deelname aan wetenschappelijke prijzen of wedstrijden.

ACKNOWLEDGMENTS

We would like to thank our promotor Prof. Dr. Bert Vaes and co-promotors Dr. Miek Smeets and Dr. Willem Raat for their guidance and advice during the development of our master thesis.

Furthermore, a special thank you to the Information Specialists from the Group Biomedical Sciences of Désiré Collen Learning Centre for their help with our search strategy.

Finally, we would like to thank our family and friends for their support.

ABSTRACT

Introduction: Heart failure is a syndrome with high mortality, morbidity and (re)hospitalization rates. Mobile health could improve self-care of heart failure patients, which in turn could improve clinical outcomes. Previous research focused mainly on telemonitoring, with the primary outcomes being hospitalizations and mortality. This review focuses on self-care as outcome.

Methods: A systematic search in five databases (Medline, Embase, CINAHL, Web of Science and Cochrane CENTRAL) was performed on the fifth of April 2022. Randomized controlled trials written in English and published starting from January 2010 were included. Three independent researchers blinded to each other used the Rayyan platform to select studies according to the in- and exclusion criteria. Only studies focusing on mHealth which actively contributed to education and self-care behaviour of patients were included. The primary outcome was patient self-care knowledge and behaviour. The secondary outcomes were hospital (re)admissions, treatment adherence, disease severity, mortality, morbidity, and quality of life. This systematic review is descriptive only, no meta-analysis was performed.

Results: Self-care behaviour improved in nine of the twelve included RCTs. This outcome was measured using different scales. There was no significant result in treatment adherence. This was only studied by one RCT. Four studies out of ten showed a significantly reduced heart failure related hospital (re)admission. An effect was shown on disease severity and morbidity by one RCT. Three studies investigated the effect of mHealth on mortality with no significant effect. Heart failure quality of life (HFQoL) was studied in seven RCTs. Short-term improvement of HFQoL was seen in two studies. Three studies showed an improvement of HFQoL at the end of the follow up time.

Conclusion: This systematic review showed promising results regarding the influence of mHealth on self-care behaviour in patients with chronic heart failure. However, the results cannot be generalized to the average heart failure population because of heterogeneity in overall study design and patient characteristics.

ABSTRACT (dutch)

Introductie: Hartfalen is een syndroom met hoge mortaliteit, morbiditeit en een hoog aantal ziekenhuisopnames. Mobile health zou zelfzorg van hartfalen patiënten kunnen verbeteren, wat zou kunnen zorgen voor betere klinische uitkomsten. Vroegere onderzoeken focussen voornamelijk op telemonitoring, waarbij de primaire uitkomst ziekenhuisopname en mortaliteit was. Deze review focust op zelfzorg als uitkomst.

Methode: Een systematische zoekopdracht in vijf databanken (Medline, Embase, CINAHL, Web of Science en Cochrane CENTRAL) werd uitgevoerd op vijf april 2022. Gerandomiseerde gecontroleerde studies geschreven in het Engels en gepubliceerd vanaf januari 2010 werden geïncludeerd. Drie onafhankelijke onderzoekers, geblindeerd voor elkaar, maakten gebruik van het Rayyan platform om studies te selecteren volgens de in- en exclusie criteria. Enkel studies die gebruik maakten van mHealth die de patiënten actief aanzetten tot betere zelfzorg en ziektekennis werden geïncludeerd. De primaire uitkomst was zelfzorg, ziekte-inzicht en gedragsverandering. De secundaire uitkomsten waren hospitalisaties, therapietrouwheid, ernst van de ziekte, mortaliteit, morbiditeit en kwaliteit van leven. Deze systematische review is enkel beschrijvend, er werd geen meta-analyse uitgevoerd.

Resultaten: Zelfzorg verbeterde in negen van de twaalf geïncludeerde RCT's. Deze uitkomst werd gemeten met verschillende schalen. Er was geen significant betere therapietrouwheid. Deze uitkomst werd in slechts één RCT bestudeerd. Vier van tien studies toonden een significant lagere hoeveelheid ziekenhuisopnames. Een effect op ernst van ziekte en morbiditeit werd in één RCT vastgesteld. Drie studies onderzochten het effect van mHealth op mortaliteit, maar toonden geen significant effect. Kwaliteit van leven gerelateerd aan hartfalen (HFQoL) werd bestudeerd in zeven studies. In twee studies was er enkel op korte termijn beterschap van HFQoL. In drie andere studies was er op het einde van de opvolgperiode nog een positief effect.

Conclusie: Deze systematische review toont veelbelovende resultaten wat betreft de invloed van mHealth op zelfzorg en zelfkennis bij patiënten met chronisch hartfalen. Deze resultaten kunnen

echter niet gegeneraliseerd worden naar de algemene hartfalen populatie door de heterogeniteit in studie design en patiënten karakteristieken.

TABLE OF CONTENTS

Introduction 1

Methods 3

Study design 3

Information sources and eligibility criteria 3

Search 3

Study selection 4

Data collection process 4

Data items 5

Quality assessment 5

Data analysis 5

RESULTS 6

Search process 6

Study characteristics 8

Primary outcome: self-care behaviour 14

Secondary outcomes (hospital (re)admissions, treatment adherence, severity of the disease, mortality, morbidity, quality of life) 18

DISCUSSION 22

Summary of main results 22

Comparison of findings with other systematic reviews 22

Secondary outcomes 23

Heterogeneity 24

Implications for the future 25

Strengths and weaknesses of this review 26

CONCLUSION 28

BIBLIOGRAPHY 29

Appendix 1 search strategy 32

Pubmed database 32

Embase 33

Web of Science Core Collection 34

Cochrane CENTRAL 35

CINAHL via EBSCO 36

Appendix 2: Inclusion and exclusion criteria 37

Inclusion criteria: 37

Exclusion criteria: 38

Appendix 3: Flowchart: Selection of studies based on title and abstract 40
Appendix 4: Risk bias assessment results and GRADE quality rating 42
Reflectieverslag – LENS, Laura 43
Reflectieverslag – OOSTERBOS, Lauren 46
Reflectieverslag – VRYSEN, Arne 49

Introduction

Heart failure (HF) is a syndrome with a high prevalence and incidence.(1, 2) Prevalence increases steeply with age, affecting mostly older patients.(3) Furthermore, in patients diagnosed with HF, mortality is also high.(4, 5) There is a 67% mortality rate within 5 years after receiving the diagnosis of HF, making it as "malignant" as some common forms of cancer.(6) Even though ample therapeutic options now exist, efficacy could improve if patients act responsible in their use, such as practicing tight medication adherence and undergoing regular follow-up.(7) Health literacy, the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions, is low in HF patients.(8, 9) This literacy is needed to practice self-care. Unfortunately, clinical guidelines in HF are often complicated as they involve monitoring symptoms, dietary and fluid restrictions, exercise regimens and the management of a plethora of medications. This makes practicing self-care complex in HF.(10)

Health education is a means to improve health literacy and self-care. Health education in HF leads to improved self-care, which in turn impacts disease evolution and mortality.(11-13) A relatively new branch in self-care is mobile health (mHealth). The Global Observatory for eHealth (GOe) defined mHealth as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices.(14) Systematic reviews often only include telehealth, with the focus on interaction between health care provider and patient when the two are separated by distance.(15) Examples are consultations through telephone usage, video chatting and monitoring of clinical markers.(16-19) Important to state is that there is always feedback provided by a care provider with instructions that the patient has to follow. Within mHealth, the focus is purely on what the patient can learn by themselves. Currently, most reviews about mHealth in combination with HF focus on transmission of clinically monitored data from the patient to a health care center or medical practitioner with clinical feedback. (20-26) The main reported primary outcomes of reviews are mortality and hospitalizations. Secondary outcomes were

HRQoL and self-care.(20-26) There are few systematic reviews that focus primarily on the effect of mHealth on knowledge and self-care. (21)

Therefore, the aim of this study was to explore the use of digital medical interventions (mHealth) in the education of adult patients with chronic HF and their caregiver(s) with respect to patient's self-care behaviour (knowledge of their disease and self-management skills). As secondary outcomes hospital (re)admissions, treatment adherence, severity of the disease, mortality, morbidity, and quality of life were explored.

Methods

Study design

A systematic review of the literature was performed by following standardized methods based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 statement and the Cochrane handbook recommendations for reporting a systematic review.(27, 28)

Information sources and eligibility criteria

Our search strategy included database searching via index terms (like Medical Subject Headings (MeSH)) that we composed with the help of the biomedical information specialist of KU Leuven Libraries -2Bergen – Learning Centre Désiré Collen (https://bib.kuleuven.be/2bergen/mgas). Several healthcare databases including Medline (via PubMed), Embase, CINAHL, Web of Science and Cochrane CENTRAL were searched on the fifth of April 2022. Articles starting from the first of January 2010 until the search date were included. This restriction in time was due to the rapid developments in medical technology. Therefore, articles published before 2010 are less relevant for our search. Both published and unpublished articles or protocols written in English were selected. Furthermore, we identified and included additional papers from the reference lists of included studies, using the snowball technique.

Search

The PICO was (P) patients with chronic HF and their caregiver, (I) mobile health interventions and (O) patient knowledge, selfcare behaviour and secondary outcomes such as hospital admissions and readmissions, treatment adherence, severity of the disease, mortality, morbidity and quality of life.

The search strategy included the following search terms: “Heart failure”, “Telemedicine”, “Mobile applications”, “Text messaging”, “Computer, handheld”, “Wearable Electronic devices”, “Cell phone”, “Fitness Trackers” and “Social Media”; both MESH terms and free text terms were searched in all databases. The full search strategy can be found in Appendix 1.

Study selection

The in- and exclusion criteria were predefined and listed in detail in Appendix 2.

First, randomized controlled trails (RCT) were included. Observational studies, case reports and case series, feasibility studies, systematic reviews and narrative reviews were excluded from our search.

Second, adult patients with chronic HF and their caregiver were the main topic of the article. Articles describing patients with multiple morbidities including HF were selected when the population of patients with HF was described separately. Articles that focus on health care providers were excluded.

Third, as the main idea of this study was to investigate the added value of the use of digital media on the patient's self-care behaviour and knowledge, all digital interventions in which the patient only participated passively, such as the use of electronic health record (EHR), teleconsultations, digital reminders or telemonitoring, were excluded. These do not include the active involvement of the patient in the health care process.

Digital interventions that were included focus on the active use by the patient, such as online education programs, text messages and interactive applications/wearables that support behavioural change in patients and teach them new skills.

Fourth, only articles in English were extracted. Fifth, only full text articles were included. To avoid publication bias non-published studies were included.

Data collection process

All citations from searches were managed using Endnote 20 Desktop for deduplication. Three independent reviewers (A.V., L.O., L.L.) screened and selected the articles in each phase of the review using Rayyan (https://www.rayyan.ai/). Disagreements were resolved by consensus or by the advice of our (co-) promotor. The flow diagram for selection is reported in Appendix 3. A log of excluded articles was maintained.

Data items

For each article, the authors, year of publication, country, design, number of patients with chronic HF or number of caregivers of patients with chronic HF, NYHA classification, and type of mobile health used were registered. As primary outcomes the effect on patient knowledge and self-management and as secondary outcomes hospital (re)admissions, treatment adherence, severity of the disease, mortality, morbidity and quality of life were obtained.

Quality assessment

Three review authors (A.V., L.O., L.L.) assessed the quality and risk of bias of all included studies using the criteria defined by the Cochrane Handbook for Systematic Reviews of Interventions. Details can be found in appendix 4. We evaluated the overall quality of the evidence supporting the outcomes using the GRADE approach. Only moderate-to-high quality studies were included to ensure the validity of the included results.

Data analysis

Our systematic review is descriptive only. No meta-analysis was performed due to heterogeneity in the interventions and the outcome measurements used. Results will be tabulated and discussed narratively.

RESULTS

Search process

Our search was structured in the PRISMA flowchart (Figure 1). The screening was performed by following the flowchart found in appendix 3. There were 147 conflicts which were discussed among the reviewers. A thorough search for full texts was performed, whereby the university library 'Leercentrum Désiré Collen' at Leuven was also consulted. Eventually, 13 articles were included in this review. After quality assessment, 12 articles representing 11 studies remained.(29-40) One article was labelled as low quality and was excluded (appendix 4).(41) No meta-analysis was performed because the conditions for conducting a good meta-analysis were not met. Specifically, there was a high level of heterogeneity in the interventions, as discussed below, which would complicate the interpretation and reliability of a meta-analysis.

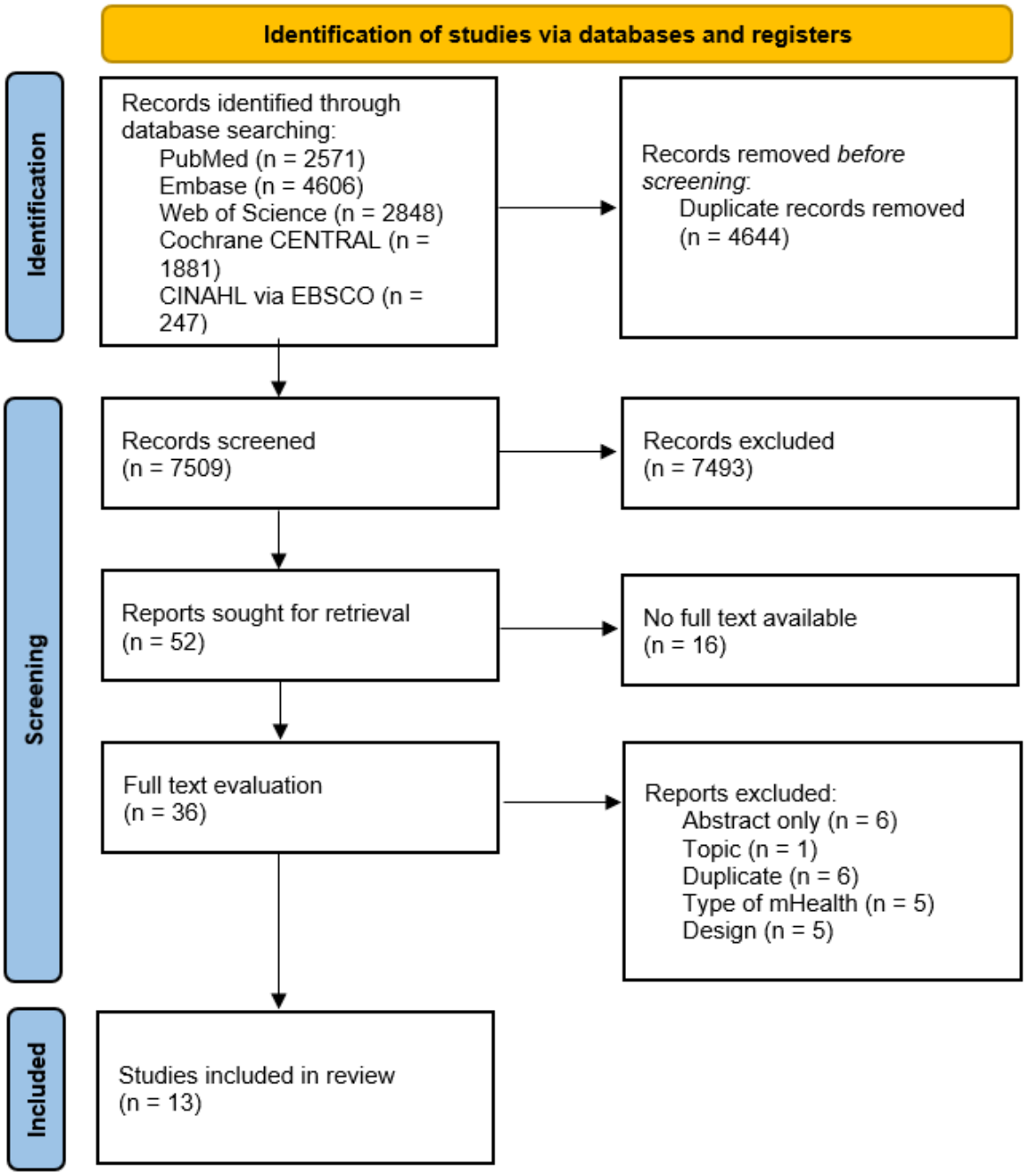


Figure 1: PRISMA Flow Chart

Study characteristics

In Table 1 and 2, all study characteristics are structurally displayed.

The 12 included studies were published between 2015 and 2022. Overall, these studies originated from all over the world. However, most studies were conducted in western countries (seven articles).(29, 31, 32, 34-37, 39, 40) Asian and eastern countries were less represented (four articles).(30, 33, 34, 38) Only one South-American country was included.(40) No selected studies were executed in the African continent.

Most studies included only a small number of participants, varying between 30 and 146.(29, 31, 32, 34, 37, 38, 40) Only a small amount of larger studies were included. (30, 33, 36, 39)

A variety of mobile health interventions were used in the included studies. Most studies used an app, others used a website, e-platforms or SMS services. Most interventions combined education with telemonitoring facilities.

The study of Wonngom et al. used an avatar app installed on a tablet computer. This app contained four sections that focused on HF knowledge and self-care.(29) Chen et al. compared an intervention with educational text messages and an intervention with structural telephone support.(30) Dorsch et al. used a mobile app (ManageHF4Life) together with a Fitbit and scale to support active daily self-monitoring and promote self-management. In the app patient education on HF was included.(31) In Jiang et al., the HOM-HEMP intervention alone (i.e. an intervention in which a nurse provided home visits and a toolkit which promotes self-management was used, this was not a form of mHealth), was compared to the HOM-HEMP intervention combined with an app. This app contained educational information, reminders for medication, registration of parameters and a chatroom to talk to a nurse.(31, 33) In Yanicelli et al., an app that contained telemonitoring features was combined with an educational functionality (FAQ section, games, health messages).(40) Wagenaar et al. tested two different interventions, a website (heartfailurematters.org) which contained useful information, and

the e-Vita Platform.(39) This platform was used for telemonitoring, but the use of the website was also stimulated.(39) Sahlin et al. used the OPTILOGG tool on a tablet computer.(37) The OPTILOGG tool contained an integrated feedback loop which suggested medication changes based on the registrations of the patient (weight, symptoms) and also interactive education.(37) This tool was also the intervention in the studies of Hagglund et al. and Melin et al.(32, 35) In Nolan et al., an interactive e-platform was used. Patients received emails that were linked to a section of the platform with multimedia materials and interactive e-tools promoting behaviour change (self-help exercises a.o.).(36) Kiyarosta et al. used an app called 'My Smart Heart', which contained reminders, educational content, educational videos, daily messaging, a medication guide, a FAQ section and registration of symptoms and parameters.(34) Lastly, in Somsiri et al., a mobile app called 'Tid Tam Jai' was used. This app had self-monitoring features, but also an educational purpose with a private messaging system between the patient and the nurse.(38)

In six studies, the interventions were monitored by clinical staff.(30, 31, 33, 34, 38, 40) In most of the studies where no clinical monitoring was present, there was an integrated feedback loop based on what the participant recorded. The participant would then receive an alert to schedule an appointment or go to the emergency department.

Cognitive impairment, illiteracy, dementia and major psychiatric illnesses were mentioned as exclusion criteria in as many as nine studies.(29, 30, 32-36, 38, 40) Two other studies mentioned in their inclusion criteria that the participant had to be able to handle the intervention or questionnaires.(37, 39) Only one article did not discriminate on this criterion.(31)

The overall mean age of the included RCTs in this systematic review was 63.78 years for the intervention group and 64.59 year for the control group.

Author	Year	Country (region)	Cases	FU time	NYHA	Clinical monitoring	Intervention	Control group	Mean age (years)	Years of data coverage
Wonngom et al.	2020	Australia	36	30 days 90 days	I-IV	No	Usual care + avatar app	Usual care	CG: 66,6 IG: 68,7	November 2018-May 2019
Chen et al.	2018	China	767	180 days	I-IV	Yes	A: Usual care + SMS B: Usual care + Structured phone call	Usual care	CG: 61 IG (A): 60 IG (B): 62	December 2011-September 2015
Dorsch et al.	2021	Michigan (US)	83	6 weeks 12 weeks	/	Yes	Discharge education with FU Mobile app fitbit weight scale	Usual care Discharge education with FU	CG: 62 IG: 60,2	March 2017-April 2019
Jiang et al.	2021	Singapore	213	6 weeks 3 months 6 months	I-IV	Yes	A: Usual care + HOM-HEMP B: Usual care + HOM-HEMP + mobile app	Usual care	CG: 68,82 IG (A): 69,08 IG (B): 66,82	June 2018 - August 2019
Yanicelli et al.	2021	Argentina	30	3 months	/	Yes	Usual care + app (weight, BP, HR, symptom measurements, education)	Usual care	CG: 52 IG: 52	August - December 2018
Wang et al.	2021	China	120	1 year	III - IV	Yes	WeChat platform	Usual care+ regular phone calls + discharge guidance	CG: 58,69 IG: 59,41	Patients admitted to the hospital in May 2017

Table 1: Study characteristics (part 1)

Author	Year	Country (region)	Cases	FU time	NYHA	Clinical monitoring	Intervention	Control group	Mean age (years)	Years of data coverage
Wagenaar et al.	2018	The Netherlands	450	3, 6 and 12 months	I - IV	A: Yes B: No	A: Website B: E-health adjusted care pathway group	Usual care	CG: 66,9 IG (A): 66,7 IG (B): 66,6	October 2013 - December 2014
Sahlin et al.	2022	Sweden	118	8 months	I - IV	No	Information sheet+ OPTILOGG tool	Information sheet + priority number to call in need	CG: 77 IG: 80	April 2018 - February 2019
Nolan et al.	2021	Canada, Toronto	231	12 months	/	No	Hybrid e-platform	Enhanced usual care with online CHF self-care education	CG: 59* IG: 60* (* Median age)	January 2014- february 2018
Hagglund et al.	2015	Sweden, Stockholm	82	3 months	II-IV	No	OPTILOGG tool	Usual care	CG: 70 IG: 66	February 2015-June 2015
Melin et al.	2018	Sweden, Stockholm	82	6 months	II-IV	No	OPTILOGG tool	Usual care	CG: 70 IG: 66	6 months
Kiyarosta et al.	2020	Iran	120	3 months	II-III	Yes	Routine care + Smart phone app My Smart Heart	Usual care	CG: 60,71 IG: 55,95	March - August 2018
Somsiri et al.	2020	Thailand, Bangkok	146	6 weeks and 8 weeks	II-III	Yes	Usual care + TTP : transitional telehealth program (mobile phone based telehealth) by a mobile app Tid Tam Jai	Usual care	CG: 61,1 IG: 60,87	8 months

Table 1: Study characteristics (part 2)

Author	Inclusion criteria	Exclusion criteria	Outcome	Limitations
Wonngom et al.	Diagnosis of HF Previous hospitalization for HF NYHA I-IV Normal cognitive function Proficient in English Informed consent	Clinically unstable Cognitive impairment	HF knowledge HF self-care behaviours HF-related readmissions satisfaction	Small sample Wide variabiltiy in HF diagnosis and number of years with the disease Only English language Ceiling effect
Chen et al.	Decompensated CHF	Deceased in hospital unwilling to participate Age < 18 years No Chinese comprehension No phone Discharged to long-term care facility cardiac surgery/heart transplant planned life expectancy < 1 year Severe mental disorder other studies	Death All-cause hospitalization Self-care behaviour Quality of Life	> 20% of HF population excluded FU based on sparse phone calls Only standardized texts
Dorsch et al.	Age > 45 years LVEF < 40% or more if contributing factors Admitted/recently discharged for acute on chronisch decompensated HF	Unstable coronary syndroms (8 weeks) Primary valvular heart disease Constrictive pericardial disease Uncorrected thyroid disease Dialysis/creat > 4.0 mg/dL Active cancer Pulmonary fibrosis Hospice candidates Not discharged to home setting Requiring a chronic inotrope	Change in Minnesota living with heart failure questionnaire Self management HF readmission	Open-label Attention control groups (strengthen behavorial interventions) Intensive usual care Wearable device and scale, more than just mobile app
Jiang et al.	Age > 21 years Clinical diagnosis of HF Understand English/Chinese Owning a smartphone (daily use) FU at home possible	Unstable angina/resting tachycardia/severe arterial hypertension Terminal illness Impaired cognitive function Reduced mobility No internet access	HF self-care Cardiac self-efficacy Anxiety and depression Health-related QoL	Consecutive sampling No evalutation of adherence to smartphone app Outcomes were Self-report Allocation possibly predictable
Yanicelli et al.	Age ≥ 18 years Diagnosis of HF Hospitalization Owning a smartphone Access to wifi, weight scale, BP monitor	Illiterate patients Patients with learning difficulties Cognitive impairment Severe depression	Self-care Treatment adherence Re-hospitalizations	Low number of patients Relatively short follw-up period Outcomes obtained in low-literacy population
Wang et al.	HF diagnosis and treatment 18-75 years NYHA III-IV Being able to use WeChat lifetime expectancy of 12 months or more Informed consent	Abnormal function of limbs Suffering from valvular heart disease or cor pulmonale Being diagnosed as insane Severe infections Uncontrollable diseases (hypertension, diabetes)	Cardiac pumping function Cardiac enzymes Self-care Quality of life Compliance Hospitalizations 6-min walking distance	Only patients with severe cardiac failure included

Table 2: Second part of study characteristics (part 1)

Author	Inclusion criteria	Exclusion criteria	Outcome	Limitations
Wagenaar et al.	Age ≥ 18 year HF diagnosis for at least 3 months Able to fill out questionnaires BP and weight measurments Access to internet and e-mail Dutch comprehension	Not mentioned	Self-care Quality of life Knowledge, satisfaction about care Mortality (all-cause, HF related, cardiovascular-related) Hospitalizations (all cause, HF related, cardiovascular-related) Number of HF hospitalization days	Low participation rate Young and healthy study population (only stable patients included) Not apllicable to all patients with HF Use of website by control group possible Basic heart failure care in The Netherlands intensive compared to other European countries
Sahlin et al.	Diagnosis of HF Complete consent form Able to handle the intervention Hospital admission for HF in the last 12 months Risk of readmission	Not mentioned	Self-care Number of HF hospitalization days Event-free survival HF admission Death Unplanned hospital visits owing to HF System adherence	Limited study size Worse kidney function and higher prevalence of diabetes in the IG Withrawal of consent in intervention group Increased probability of hospitalisation due to AF in intervention group Control group got more than usual care (information sheet) knowledge measuring instrument subpar
Nolan et al.	Age ≥18 years CHF diagnosis for at least 3 months No worsening of CHF 1 month before recruitment Optimal and stable pharmacotherapy Comprehension of English or French Access to internet and email services Written informed consent	Renal failure Liver disease Poorly controlled diabetes (Symptomatic) hypotension Hypertension despite antihypertensive therapy Uncorrected valvular cardiomyopathy Predominant right-sided heart failure Acute myocardial infarction Planned or cardiac surgery within 4 weeks before enrollment (Planned) heart transplantation Diagnosis of a major psychiatric disorder Drug/alcohol abuse in the past year	HRQL Program engagement Total CHF self-care behaviors Diet Exercise capacity Daily activity Adherence to self-care behaviour	knowledge measuring instrument subpar No access on mobile phone Tailoring at intermittent time points instead of dynamic tailoring. No clinical outcomes (hospitalization, ER visits, mortality or cost)
Hagglund et al.	Age > 18 years Recent hospitalization for HF HF diagnosis (NYHA II-IV) Treatment with diuretics Patients referred to primary care	Structured/nurse-led follow-up at HF clinic Severe cognitive impairment Life expectancy < 6 months Participation in another study affecting treatment	Self care behavior HRQL Quality of life HF knowledge Number of days in hospital Adherence	No database inclusion Scholarship by Swedish National Quality Registry of HF (RiksSvikt) OPTILOGG system used in the study was provided by care ligo, paid a small stipend for each included patient.
Melin et al.	Age > 18 years Recent hospitalization for HF	Severe cognitive impairment Referral to a nurse-led HF clinic, Life expectancy < than 6 months Participation in another study affecting treatment	Self care behavior HRQL Quality of life HF knowledge Number of days in hospital Adherence	No database inclusion Scholarship by Swedish National Quality Registry of HF (RiksSvikt) OPTILOGG system used in the study was provided by care ligo, paid a small stipend for each included patient.
Kiyarosta et al.	Owning/using smartphone or android tablet NYHA II or III HF hospitalization of Fluently and in Persian language	Chronic diseases (Cancer, severe kidney disease) Dementia Amnesia Involved in other studies at the same time Failure to use app > 1 week Death Hospitalization of patient for any reason other than specific disease	Self-care behaviour	Apps could not be installed on mobile phones with IOS system. Only class II en III NYHA were included, which requires frequent hospitalization
Somsiri et al.	Age > 18 years HF diagnosis < 12 months NYHA II-III < 12 months Access to a mobile phone and internet Ability to use mobile app	Cognitive impairment Cancer Chronic kidney disease Surgery planned within 2 months Dialysis	Functional status Rehospitalization Care satisfaction	Participation was discontinued if less than 30 days of self-monitoring data were submitted. = attrition bias Substantial exclusion due to HF diagnosis longer than12 months ago

Table 2*: Second part of study characteristics (part 2)*

Primary outcome: self-care behaviour

All studies reported a self-care outcome. Overall, nine out of twelve studies noted some sort of improvement in the intervention group, however not all studies noted a lasting change.(30, 32-37, 39, 40) All results are displayed in Table 3.

Different scales were used to measure these outcomes. Six studies used the European HF self-care behaviour scale (EHFScB). (32, 34, 35, 37, 39, 40) Two of them used the EHFScB-9 scale (Figure 2). (39, 40) The others used the older version, the EHFScB-12 scale (Figure 3). (32, 34, 35, 37, 42) All found statistically significant improvements. Three articles reported an improvement in self-care after three months (32, 34, 40), Melin et al. after six months.(35) Wagenaar et al. also reported an improvement in self-care at three and six months, but not at twelve months.(39) Sahlin et al. reported the longest lasting improvement in this group, with significant differences after eight months.(37)

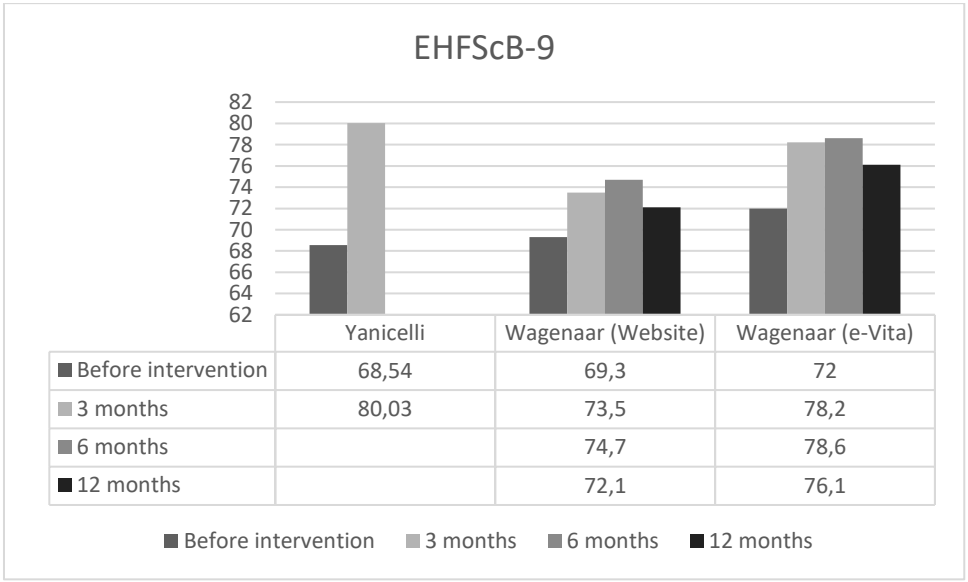


Figure 2: The European Heart Failure Self-care Behaviour scale (EHFScB-9): scores in the intervention group (high score indicate better self-care behaviours)

Yanicelli et al.(40) and Wagenaar et al.(39)

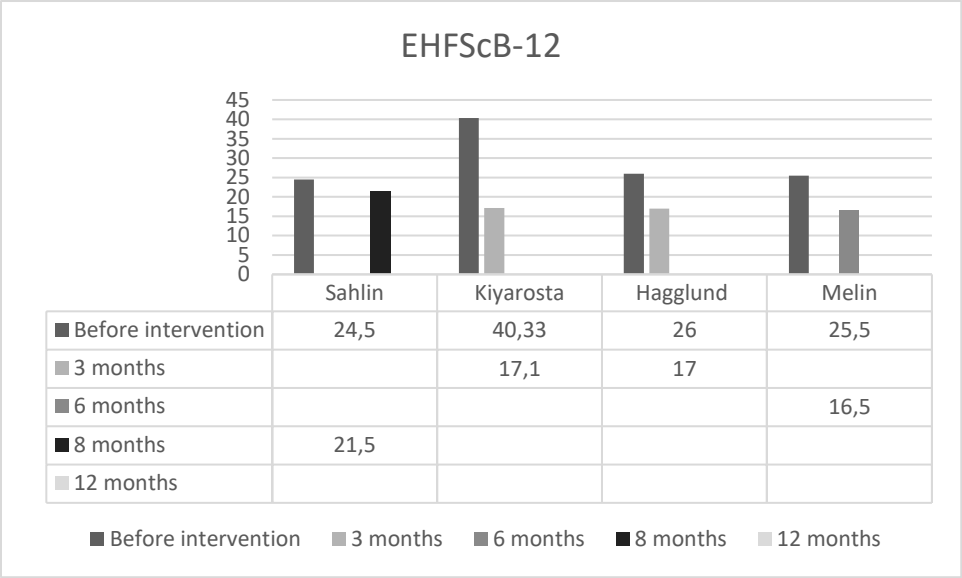


Figure 3: The European Heart Failure Self-care Behaviour scale: scores in the intervention group (higher scores indicate worse self-care behaviours)

Sahlin et al.(37) Kiyarosta et al.(34) Hagglund et al.(32) Melin et al.(35)

Three studies used the Self-care of Heart Failure Index (SCHFI) (Figure 4). Two of them did not notice a difference in Self-Care behaviour (Wonngom and Dorsch).(29, 31) Jiang et al. noticed a difference at all follow-up times.(33)

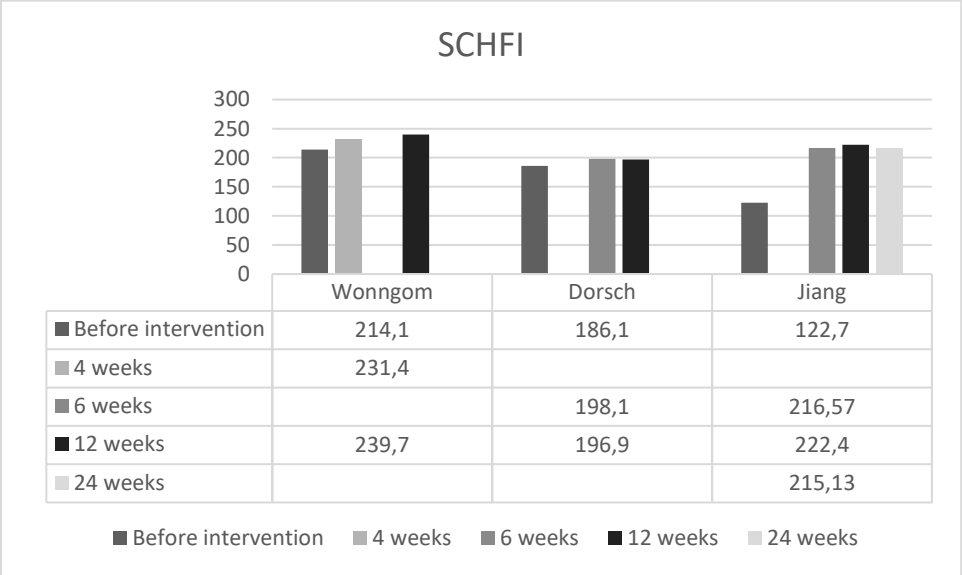


Figure 4: Self-care of Heart failure Index: scores in the intervention group

Wonngom et al.(29) Dorsch et al.(31) Jiang et al.(33)

Somsiri et al. used the emotional self-disclosure scale (ESDS) for functional status, which was higher in the intervention group at six weeks.(38)

Both Chen et al. and Nolan et al. used a collection of measurements of self-care behaviour, as was stated in Table 1 and 2.(30, 36) Chen et al. reported a significant change in self-care behaviour at 180 days.(30) Nolan et al. described a significant difference at 12 months follow up.(36)

Four studies also reported disease knowledge as an outcome.(29, 32, 35, 39) Wonngom et al. noted an improvement in knowledge after 90 days when compared to usual care.(29) Wagenaar et al. also stated an increase in knowledge after three months, but not after six or twelve months.(39) Hagglund and Melin et al. saw an increase after three and six months.(32, 35)

Author	Self-Care	Author	Self-Care
Wonngom et al.	(1) Increase in HF knowledge from baseline at 30 days (13.3, ↑15.7%) and 90 days (14.1, ↑22.6%) (p=.0009, 95% CI 1.159, 4.0403) When compared to UC only significant difference at 90 days (F(1, 32)=11.358, P=.002, partial η2=0.262, 95% CI −2.755 to −0.686 (2) Self-care behaviour: no significant difference (P=.129, 95% CI: −8.751 to 0.440)	Sahlin et al.	Significant improvement after 8 months (EHFScB) (CG 26, IG 21.5; p=0.014)
Chen et al.	Signicant change in self-care behaviour between SMS - STS and control group (medication compliance ((OR 1.136, 95% CI 1.01-, 1.275, P= 0.029), (OR 1.171, 95% CI 1.047-11.309, P= 0.005))) (water restriction ((OR 1.151, 95% CI 1.001- 11.324, P= 0.046) , OR 1.212, 95% CI 1.060-11.386, P= 0.004)))	Nolan et al.	Significant improvement in self-care behaviour in IG at 12 months (p=0.002)
Dorsch et al.	Not significant (SCHFI) (P=0.78)	Hagglund et al.	(1) Significant improvement in self-care after 3 months (EHFScB), p <0.05 (median IG: 17 [IQR: 13, 22] and CG: 21 [IQR: 17, 25]) (2) Improvement in disease knowledge, but not significant (p=0.4)
Jiang et al.	Both experimental groups had a significant difference (SCHFI) from the baseline group (F=7.971,p<0.001), but no difference between eachother (p>0,05) A: Significant immediately after and at 6 months FU (p<0.05) B: Significant difference between control at all follow-ups (p<0.05)	Melin et al.	(1) Self care behaviour increased significantly after 6 months in the IG (EHFScB-9) (median IG 16.5 [IQR, 12-22], median CG 23.5 [IQR, 18.8-30.0]; P <0.05) (2) Significant improvement in disease knowledge after 6 months in the IG (p<0.05)
Yanicelli et al.	Significant improvement in self-care in IG after 3 months (EHFScB) (69.43 vs 80.03, p=0.004)	Kiyarosta et al.	Significant improvement after 3 months in IG (EHFScB) (p<0,001). (mean IG 17.1±2.16 ; mean CG 17.1±2.16)
Wagenaar et al.	(1) Self-care: significant at 3 (p<0.001)and 6 months (p=0.070) follow-up for both interventions, not at 12 months (p=0,184) (EHFScB questionnaire) (2) Disease knowledge (DHFk: significant after 3 months (E-health intervention)(p=0.014); not after 6 or 12 months, not significant in de Website intervention arm	Somsiri et al.	Overall functional status (ESDS scale) was significantly higher in the IG at 6 (p<0.001) and 8 weeks (p<0.001)

Table 3: Primary outcome
Abbreviations: HF = heart failure, CI = confidence interval, IG = intervention group, CG = control group, STS = structured telephone support, OR = odds ratio, SCHFI = Self-Care Heart Failure Index, EHFScB = European Heart Failure Self-care Behaviour, IQR = interquartile range, FU = follow-up, DHFk = Dutch Heart Failure knowledge, ESDS = Emotional Self-Disclosure Scale

Secondary outcomes (hospital (re)admissions, treatment adherence, severity of the disease, mortality, morbidity, quality of life)

As shown in Table 4 secondary outcomes were treatment adherence, hospital (re)admissions, disease severity, mortality, morbidity, and quality of life.

Treatment adherence was only investigated in one study by using the Morisky Modified Scale (MMS). There was no significant difference between the intervention group and control group.(40)

In six of the studies, there was no significant difference in hospital (re)admission (Figure 5). (29, 31, 32, 35, 39, 40) In four other studies, there was a significant reduction in HF related hospital (re)admission amongst the intervention group.(30, 33, 37, 38) Two studies did not investigate (re)hospitalization as a secondary outcome.(34, 36)

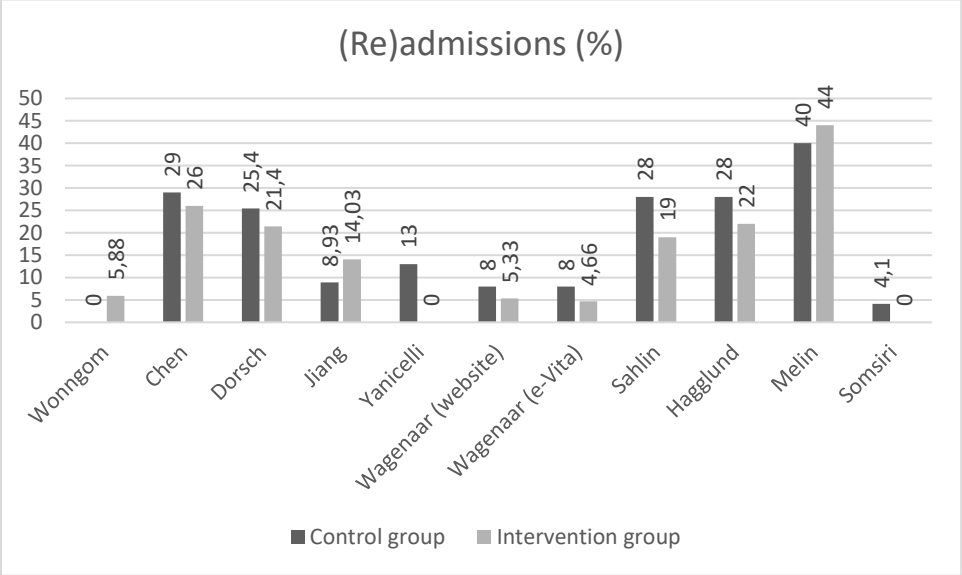


Figure 5: Percentage of heart failure related (re)admissions in both control and intervention groups(29-35, 37-40)

Disease severity (New York Heart Association (NYHA)), only measured in one study, was more severe in the control group at six weeks follow up and at three months follow up.(33) Morbidity was also only investigated in this study, where there was significantly less depression (Hospital anxiety and depression scale (HADS)) in group A (usual care + HOM-HEMP) at every moment of follow up and in group B (usual care + HOME-HEMP + app) at six months follow up.(33)

Mortality was only measured in three studies as a secondary outcome but no significant difference was found (Figure 6).(30, 37, 39)

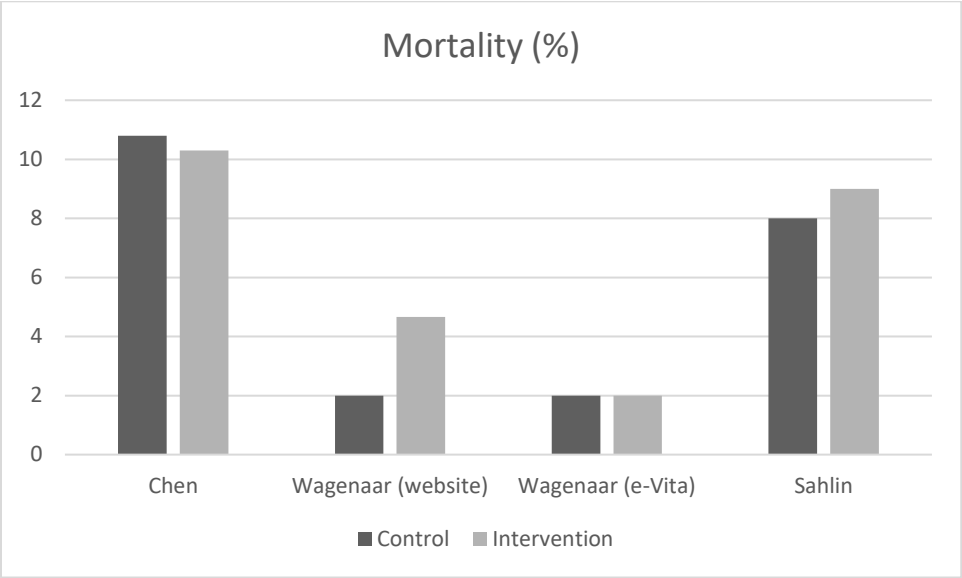


Figure 6: Percentage of heart failure related mortality in both control and intervention groups

Chen et al.(30) Wagenaar et al.(39) Sahlin et al.(37)

HF related Quality of life (HFQoL) was measured with two different types of questionnaires. Four studies investigated HFQoL with the Minnesota Living with Heart Failure Questionnaire (MLHFQ) (Figure 7). (30, 31, 33, 39) Three studies used the Kansas City Cardiomyopathy Questionnaire Overall Summary (KCCQ-OS).(32, 35, 36) Dorsch et al noted a significant improvement in HFQoL at six weeks but not after a follow up of twelve weeks. (31)

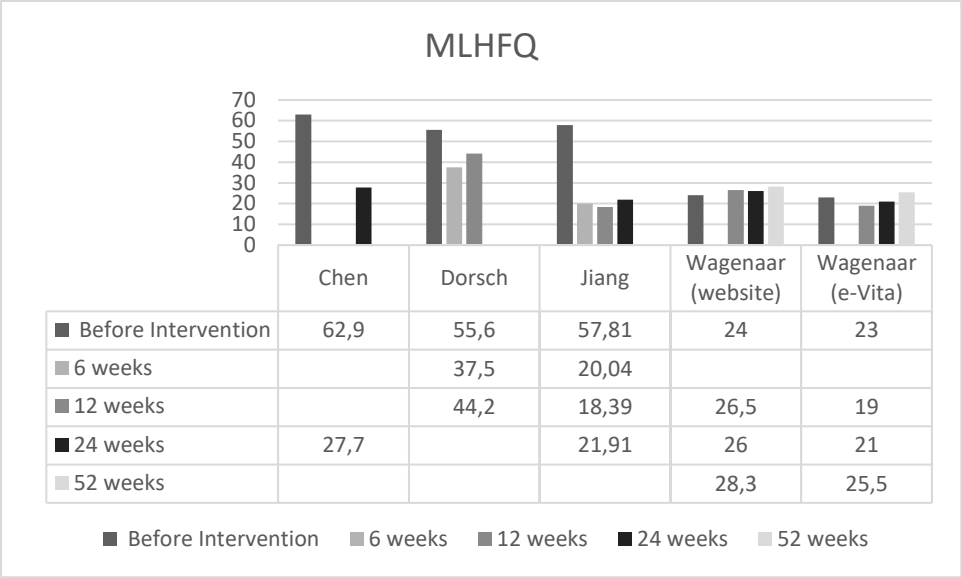


Figure 7: Minnesota Living with Heart Failure Questionnaire: scores in the intervention group

Chen et al.(30) Dorsch et al.(31) Jiang et al.(33) Wagenaar et al.(39)

Three articles found a significantly better HFQoL after twelve weeks (three months) follow up and six months.(32, 35, 39) In the study of Wagenaar et al. the HFQoL was significantly better after three and six months in the e-health intervention, but not after twelve months. There was no significantly better HFQoL in the website intervention group in any follow up period.(39)

Jiang et al. reported overall quality of life separated from the physical dimension of HFQoL.(33) The study noted a significantly better physical dimension of HFQoL in group A (usual care + HOM-HEMP) and group B (usual care + HOM-HEMP + app) compared to the control group in all follow-up times. Group B had an overall significantly better HFQoL in all follow-up times, in group A overall HFQoL was only reported significantly better at six weeks and three months compared to the control group.(33)

Author	*Quality of Life*	*Hospital (re)admissions*	*Other Secondary Outcomes*
Wonngom et al.		Not significant (P=0.395)	
Chen et al.	Not significant (MLHFQ)(P= 0.703)	Both SMS an STS significantly reduced readmission in 180 days ((OR 0,790, 95% CI 0,632-0,988, P= 0.037), (OR 0,716, 95% CI 0,568-0,904, P= 0.004))	Mortality: not significant (P= 0.694)
Dorsch et al.	Significant at 6 weeks, but not at 12 weeks (MLHFQ) (6 weeks: mean 37.5, SD3.5 vs mean 48.2, SD 3.7; P=0.04, 12 weeks: mean 44.2, SD 4 vs mean 45.9, SD 4; P=0.78)	Not significant (P=0.78)	
Jiang et al.	A: Better overall HRQoL at 6 weeks and 3 months (MLHFQ) (p<0.001) B: Better overall HRQoL at all FU's (MLHFQ) (p=0.005)	Significant difference in hospital addmissions an unplanned A&E visits at 6 months FU for group B (p=0.006)	Disease severity: More "severe" disease in control group, measured at 6 week and 3 month FU (p=0.001) Morbidity: A: Significantly less depression on all FU (HADS) (p<0.05) B: Significantly less depression at 6 months FU (HADS) (p=0.039)
Yanicelli et al.		No significant difference, but 2 risky situations were noted in the IG and hospitalizations were avoided (p=0.5)	Treatment adherence: no significant difference (MMS questionnaires)(p=0.1)
Wagenaar et al.	Significant after 3 (p=0.029) and 6 months (p=0.003)(E-health intervention), not after 12 months; not significant in the Website intervention arm (MLHFQ)	(1) All-cause: not significant (HR 0,85 (95% CI 0,59-1,21)) (2) Cardiovascular-related: not significant (3) HF-related: not significant (HR 0,57 (95% CI 0,23-1,45)	Mortality: (1) All-cause: not signficant (HR 2.82 (95% CI 0.90–8.87)) (2) Cardiovascular related: not significant (3) HF-related: not significant(HR 1,03 (95% CI 0,21-5,11))
Sahlin et al.		Significant for HF related admissions (p=0.044), not significant for all-cause hospitalizations (p= 0.32)	Mortality: Not significant (p=0.32)
Nolan et al.	Not significant (KCCQ-OS) (p=0.51)		
Hagglund et al.	Significant higher score in the IG after 3 months (KCCQ) (p<0.05)	Not significant for HF admissions, but significantly less in hospital days in the IG after 6 months (p<0.05)	
Melin et al.	Significant higher score in IG after 6 months (KCCQ) (p<0.05)	Not significant for HF admissions, but significantly less in hospital days in the IG after 6 months (p<0.05)	
Kiyarosta et al.			
Somsiri et al.		Significant lower hospitalization rate in the IG 6 (p<0.001) and 8 (p<0.001) weeks post-intervention	

Table 4: Secondary outcomes
Abbreviations: MLHFQ = Minnesota Living with Heart Failure Questionnaire, STS = structured telephone support, OR = odds ratio, CI = confidence interval, SD = standard deviation, HRQoL = Health Related Quality of Life, FU = follow-up, A&E = Accident & Emergency, HADS = Hospital Anxiety and Depression Scale, IG = Intervention Group, MMS = Morisky Modified Scale, HR = Hazard Ratio, HF = Heart Failure, KCCQ-OS = Kansas City Cardiomyopathy Questionnaire Overall Score

DISCUSSION

Summary of main results

This systematic review aimed to gain insight in the effect of mobile health to improve the patients' self-care behaviour. Despite the heterogeneity of the studies, nine of twelve articles showed an improvement in self-care behaviour in the group in which a mobile health intervention was used. Only three studies had HF knowledge as an outcome. All of them showed an improvement in disease knowledge, although in Wagenaar et al. this effect faded with a longer follow-up duration.(39) The secondary outcomes were less represented in the studies, except for hospital (re)admissions and quality of life. The majority of these studies showed non-significant results for these outcomes.

Comparison of findings with other systematic reviews

Six other systematic reviews have been published on the topic of mobile health in HF. (21-26) Five out of six differ in conceptualization of mobile health compared to our study. They focused only on transmission of clinically monitored data from the patient to a health care center or medical practitioner with clinical feedback.(22-26) In Kitsiou 2021 et al., a study of sixteen RCTs, the main focus of twelve trials is remote monitoring and clinical feedback. A subgroup of four trials met our intervention description without data transmission or clinical support services.(24) In Cajita et al. the mHealth interventions were exclusively monitoring systems, even including invasive monitoring such as an implantable defibrillator.(22) All RCTs in Son et al. focused on telemonitoring, reminder text messages and nurse led videocalls.(26) In the study of Kitsiou et al 2015, an overview of 15 systematic reviews, interventions included telemonitoring, video consultation and artificial intelligence voice response.(24) Carbo et al. included exclusively telemonitoring with clinical feedback via telemedical interventions.(23)

The systematic review of Allida et al. (2020) did focus on the same intervention: mHealth delivered education programs.(21) Outcomes were HF knowledge (Dutch HF knowledge Questionnaire), self-efficacy (Self efficacy for managing chronic disease scale, EHFBS, SHFI) and HRQoL (KCCQ, MLHFQ).

This study included five RCTs of which three were also included in our study (Wagenaar 2019, Chen 2016 and Hagglund 2015). The study of Bashi et al. was a pilot study and the study of Jalali et al. was not found in any of the consulted databases and were therefore excluded.(21) The included studies in Allida et al. showed no difference in patient knowledge. There were uncertain results regarding self-efficacy, self-care and HFQoL. For HF-related hospitalizations there was no difference found in comparison to the usual care group. All studies were rated as low quality of evidence.(21) Our study included twice as many RCTs because more RCTs were published after 2020. This might explain the difference between our results and those of Allida et al..(21) This could implicate that the rapid technological and digital evolution in the medical world, partly due to the COVID-19 pandemic, ushered in a new series of RCTs in recent years, with more modern mHealth and intervention approaches.

Secondary outcomes

The secondary outcomes have not been investigated much in the included studies. Treatment adherence did not improve in the study of Yanicelli et al., the only study who compared treatment adherence after three months. Only 30 participants were included in this study, so there is too little evidence to draw conclusions about the influence of the use of mobile health on treatment adherence.(40)

Hospital (re)admissions were investigated more extensively, in ten studies. Six of them noted no significant effect of the use of mobile health on hospital (re)admissions, four of them did.(30, 33, 37, 38) Hospital (re)admissions are believed to be closely dependent on level of self-care ability, because many (re)admissions are the consequence of bad adherence to the medication or to the low-sodium diet.(24) Also, hospitalizations are the largest source of all annual HF management costs.(24) This makes this outcome very interesting for further research. In this systematic review, it seems as if there is no convincing positive effect of the use of mHealth on hospital (re)admissions.

Disease severity and morbidity was only measured in one study, this is too little evidence to draw any conclusions.(33) HF related mortality was an outcome in three studies, in all of these, the mobile health intervention had no significant effect.(30, 37, 39)

The last secondary outcome, quality of life, was measured in seven studies.(30-33, 35, 36, 39, 40) Here, different scales to measure this outcome were used. Mixed results were noted and overall there was no convincing evidence that the use of a mobile health intervention has a positive impact on HF related quality of life.

Heterogeneity

The most important limitation was the large heterogeneity between the studies. First with respect to the duration of follow-up, ranging from six weeks to one year. Since most studies had a relatively short follow-up time, it is hard to guess what the effect of the intervention is in the long run. Wagenaar et al. was one of the studies with a longer follow-up period, and this study noted significant improvements in self-care behaviour and quality of life at three and six months follow-up time, but not anymore at 12 months.(39) This might suggest that there is a diminishing effect of the intervention in time, or a worse compliance with the intervention over time. Due to the shorter follow-up periods in most of the other studies in this systematic review, no good comparison could be made on this domain. While the time it takes to make behavioural changes falls in this time window, the time it takes to maintain this behavioural change may be longer.(43)

Second, the mean age of the participants in almost all of the included studies was lower than the mean age of HF patients in Europe, which is 77 years, leaving uncertainty about the feasibility in a real-world HF population.(44)

Third, all but one included study had cognitive impairment, dementia, psychiatric problems, or illiteracy in their exclusion criteria. According to the World Health Organisation, the prevalence of dementia increases with age.(45) Therefore, the results cannot be extended to those who live with HF

and are cognitively impaired. We also believe that there is a generation gap in how well people can handle technological devices. Today's youth and (younger) adults have grown up with all kinds of technological devices. This is in contrast to the current elderly population, in which HF is the most prevalent.(44) In 20 to 30 years from now, it can be expected that being able to use technological devices by the elderly will be less of a problem than it is now.

Fourth, all kinds of mobile health interventions were used in the studies. Only two trials used the same intervention (i.e. the OPTILOGG system).(32, 35, 37) As a result of this heterogeneity in the interventions, the studies cannot be compared one-to-one. In some studies, the mHealth intervention was guided by health professionals like nurses or specialists, by monitoring the registrations of the patients or by calling the patients when an urgent situation occurred. In others, there was no professional involved and the system alerted the patient when an intervention was needed or there was an integrated feedback loop based on the personal data of the patient in question. Involvement of professionals could interfere with the patients' development of independent self-care skills. (24)

Implications for the future

No clear deductions can be made. Yet it seems feasible that mHealth will continue to grow over the coming years. To solidify the evidence of improved self-care further studies are needed. It seems plausible that mobile health will improve self-care, but one must be careful of possible pitfalls. Some of these are described below.

In the future, it would be valuable to look at how patients with cognitive impairment could be included. Cognitive impairment would make it hard to use these apps, but caretakers or home nurses could be involved. By increasing their knowledge, the patient could benefit.

Future apps should be streamlined, especially in terms of layout, user interface and ease of use. As a result, patients with less electronic literacy could find their way to this application. Interpreting results

would also become easier, due to less differences in the intervention group. Also, more studies with a longer follow-up time are necessary to make a better statement on this issue.

All except one of the studies had a moderate bias level. The most important contributing factor would be the Hawthorne effect, as they fail to blind both patient and assessor. Approaches like Nolan et al. could be used to ameliorate such bias possibilities. There was access to e-platforms in both the control group and intervention group.(36)

Lastly, the dissimilarity in how self-care behavioural changes were measured greatly impeded the correct analysis of the data and the formulation of a conclusion. A decision should be made on which questionnaire should be the golden standard of evaluating self-care in HF patients.

Mobile health and HF could easily be linked, and the potential health benefits could therefore be significant. Larger effects could be expected with severe HF patients or patients in places where usual care is of a lower level, as was already described by Wagenaar et al. (39) At the moment however, it appears that it would rather be used as an add-on therapy in selected cases, as the groups mentioned above cannot be treated by these means at this time.

Strengths and weaknesses of this review

The strength of this systematic review is the fact that all steps were performed by all three reviewers separately and blinded to each other. Any conflicts between the reviewers regarding the in- or exclusion of a study were discussed among them, and if necessary with the (co-)promotor(s). A rigorous methodology was used as described in the methods section. This systematic review adds to the existing literature by focusing on the influence of mHealth on self-care behaviour in particular.

This study also has weaknesses. No meta-analysis was performed due to the great level of heterogeneity as mentioned above. Only articles in the English literature were included, so articles written in other languages were missed. All but one study (Nolan et al., i.e. high quality) were of moderate quality.(29-40) Blinding of both assessors and participants is hard due to the nature of the

interventions, so most studies suffered from the Hawthorne effect. Although the included studies originated from all over the world, most were performed in Western or other well-developed countries. The results of this study are not applicable to older patients with memory problems or multimorbidity.

CONCLUSION

This systematic review of twelve randomized controlled clinical trials showed promising results regarding the influence of mHealth on self-care behaviour in patients with chronic HF. However, the results cannot be generalized to the average HF population as the randomized controlled trials all had different inclusion criteria, types of mobile health, a low mean age of patients and different scales to measure improvements or deteriorations. Further investigations should focus on streamlining these factors, improving reliability, applicability, and homogeneity.

BIBLIOGRAPHY

1. Tomasoni D, Adamo M, Lombardi CM, Metra M. Highlights in heart failure. ESC Heart Fail. 2019;6(6):1105-27.
2. Van Riet EES, Hoes AW, Wagenaar KP, Limburg A, Landman MAJ, Rutten FH. Epidemiology of heart failure: the prevalence of heart failure and ventricular dysfunction in older adults over time. A systematic review. European Journal of Heart Failure. 2016;18(3):242-52.
3. Mosterd A, Hoes AW. Clinical epidemiology of heart failure. Heart. 2007;93(9):1137-46.
4. Bleumink G, Knetsch A, Sturkenboom M, Straus S, Hofman A, Deckers J, et al. Quantifying the heart failure epidemic: prevalence, incidence rate, lifetime risk and prognosis of heart failure The Rotterdam Study. European Heart Journal. 2004;25(18):1614-9.
5. McDonagh TA, Metra M, Adamo M, Gardner RS, Baumbach A, Böhm M, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. European Heart Journal. 2021;42(36):3599-726.
6. Tsao CW, Lyass A, Enserro D, Larson MG, Ho JE, Kizer JR, et al. Temporal Trends in the Incidence of and Mortality Associated With Heart Failure With Preserved and Reduced Ejection Fraction. JACC Heart Fail. 2018;6(8):678-85.
7. Unverzagt S, Meyer G, Mittmann S, Samos F-A, Unverzagt M, Prondzinsky R. Improving Treatment Adherence in Heart Failure. Deutsches Ärzteblatt international. 2016.
8. Cajita MI, Cajita TR, Han H-R. Health Literacy and Heart Failure. Journal of Cardiovascular Nursing. 2016;31(2):121-30.
9. Kindig DA, Panzer AM, Nielsen-Bohlman L. Health literacy: a prescription to end confusion. 2004.
10. Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE, Drazner MH, et al. 2013 ACCF/AHA Guideline for the Management of Heart Failure. Circulation. 2013;128(16):e240-e327.
11. Świątoniowska N, Sławuta A, Dudek K, Jankowska K, Jankowska-Polańska B. The impact of health education on treatment outcomes in heart failure patients. Advances in Clinical and Experimental Medicine. 2020;29(4):481-92.
12. Baldewijns K, Brunner-La Rocca H-P, De Maesschalck L, Devillé A, Boyne J. Unravelling heart failure nurses' education: Content comparison of heart failure nurses' education in three European Society of Cardiology states and the Heart Failure Association heart failure curriculum. European Journal of Cardiovascular Nursing. 2019;18(8):711-9.
13. Oliveira APDD, Cavalcante AMRZ, Carneiro CDS, Santos VB, Moorhead S, Lopes JDL, et al. Health education: the effectiveness of interventions in patients with heart failure. Revista Brasileira de Enfermagem. 2020;73(2).
14. Misha Kay JS, Marina Takane. mHealth: New horizons for health through mobile technologies. Switzerland: WHO; 2011. Contract No.: ISBN 978 92 4 156425 0.
15. World Health Organization. Division of Health Promotion E. Global diffusion of eHealth: Making universal health coverage achievable. Geneva; 2016. Contract No.: 978-92-4-151178-0.
16. Berkley R, Bauer SA, Rowland C. How telehealth can increase the effectiveness of chronic heart failure management. Nursing times. 2010;106(26):14-5.
17. Baker LC, MacAulay DS, Sorg RA, Diener MD, Johnson SJ, Birnbaum HG. Effects of care management and telehealth: A longitudinal analysis using medicare data. Journal of the American Geriatrics Society. 2013;61(9):1560-7.
18. Browning SV, Clark RC, Poff RM, Todd D. Telehealth monitoring: a smart investment for home care patients with heart failure? Home healthcare nurse. 2011;29(6):368-74.
19. Cao G, Fan C, Liu Y, Huang H, Li J, Liang J, et al. A telehealth program benefits discharged patients with heart failure. Acta Cardiologica. 2022:1-8.
20. Dake V. Remote Monitoring of Patients with Heart Failure: An Overview of Systematic Reviews. SSRN. 2021.
21. Allida S, Du H, Xu X, Prichard R, Chang S, Hickman LD, et al. mHealth education interventions in heart failure. Cochrane Database Syst Rev. 2020;7(7):Cd011845.

22. Cajita MI, Gleason KT, Han HR. A Systematic Review of mHealth-Based Heart Failure Interventions. J Cardiovasc Nurs. 2016;31(3):E10-22.
23. Carbo A, Gupta M, Tamariz L, Palacio A, Levis S, Nemeth Z, et al. Mobile Technologies for Managing Heart Failure: A Systematic Review and Meta-analysis. Telemed J E Health. 2018.
24. Kitsiou S, Paré G, Jaana M. Effects of home telemonitoring interventions on patients with chronic heart failure: an overview of systematic reviews. J Med Internet Res. 2015;17(3):e63.
25. Kitsiou S, Vatani H, Paré G, Gerber BS, Buchholz SW, Kansal MM, et al. Effectiveness of Mobile Health Technology Interventions for Patients With Heart Failure: Systematic Review and Meta-analysis. Can J Cardiol. 2021;37(8):1248-59.
26. Son YJ, Lee Y, Lee HJ. Effectiveness of Mobile Phone-Based Interventions for Improving Health Outcomes in Patients with Chronic Heart Failure: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2020;17(5).
27. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Bmj. 2021;372:n71.
28. Higgins JPT TJ, Chandler J, Cumpston M, Li T, Page MJ, Welch VA Cochrane Handbook for Systematic Reviews of Interventions: Cochrane; 2022.
29. Wonggom P, Du H, Clark RA. Evaluation of the effectiveness of an interactive avatar-based education application for improving heart failure patients' knowledge and self-care behaviours: A pragmatic randomized controlled trial protocol. J Adv Nurs. 2018;74(11):2667-76.
30. Chen C, Li X, Sun L, Cao S, Kang Y, Hong L, et al. Post-discharge short message service improves short-term clinical outcome and self-care behaviour in chronic heart failure. ESC Heart Fail. 2019;6(1):164-73.
31. 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):e26185.
32. Hägglund E, Lyngå P, Frie F, Ullman B, Persson H, Melin M, et al. Patient-centred home-based management of heart failure. Findings from a randomised clinical trial evaluating a tablet computer for self-care, quality of life and effects on knowledge. Scand Cardiovasc J. 2015;49(4):193-9.
33. Jiang Y, Koh KWL, Ramachandran HJ, Nguyen HD, Lim S, Tay YK, 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.
34. Nahid K, Tahereh G, Farah N, Mahshid F, Shima H. The effect of using smartphone applications on self-care in patients with heart failure. Nursing Practice Today. 2020;7(4).
35. Melin M, Hägglund E, Ullman B, Persson H, Hagerman I. Effects of a Tablet Computer on Self-care, Quality of Life, and Knowledge: A Randomized Clinical Trial. J Cardiovasc Nurs. 2018;33(4):336-43.
36. Nolan RP, Ross HJ, Farkouh ME, Huszti E, Chan S, Toma M, et al. Automated E-Counseling for Chronic Heart Failure: CHF-CePPORT Trial. Circ Heart Fail. 2021;14(1):e007073.
37. Sahlin D, Rezanezad B, Edvinsson ML, Bachus E, Melander O, Gerward S. Self-care Management Intervention in Heart Failure (SMART-HF): A Multicenter Randomized Controlled Trial. J Card Fail. 2022;28(1):3-12.
38. Somsiri V, Asdornwised U, O'Connor M, Suwanugsorn S, Chansatitporn N. Effects of a Transitional Telehealth Program on Functional Status, Rehospitalization, and Satisfaction With Care in Thai Patients with Heart Failure. Home Health Care Management & Practice. 2021;33(2):72-80.
39. Wagenaar KP, Broekhuizen BDL, Jaarsma T, Kok I, Mosterd A, Willems FF, et al. Effectiveness of the European Society of Cardiology/Heart Failure Association website 'heartfailurematters.org' and an e-health adjusted care pathway in patients with stable heart failure: results of the 'e-Vita HF' randomized controlled trial. Eur J Heart Fail. 2019;21(2):238-46.
40. Yanicelli LM, Goy CB, González VDC, Palacios GN, Martínez EC, Herrera MC. Non-invasive home telemonitoring system for heart failure patients: A randomized clinical trial. J Telemed Telecare. 2021;27(9):553-61.

41. Wang ZR, Zhou JW, Liu XP, Cai GJ, Zhang QH, Mao JF. Effects of WeChat platform-based health management on health and self-management effectiveness of patients with severe chronic heart failure. World J Clin Cases. 2021;9(34):10576-84.
42. Jaarsma T, Arestedt KF, Mårtensson J, Dracup K, Strömberg A. The European Heart Failure Self-care Behaviour scale revised into a nine-item scale (EHFScB-9): a reliable and valid international instrument. Eur J Heart Fail. 2009;11(1):99-105.
43. Kwasnicka D, Dombrowski SU, White M, Sniehotta F. Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. Health Psychol Rev. 2016;10(3):277-96.
44. Gerber Y, Weston SA, Redfield MM, Chamberlain AM, Manemann SM, Jiang R, et al. A contemporary appraisal of the heart failure epidemic in Olmsted County, Minnesota, 2000 to 2010. JAMA Intern Med. 2015;175(6):996-1004.
45. Prince M, Maëlenn G, Matthew P. The Epidemiology and Impact of Dementia -

Current State and Future Trends. WHO Thematic Briefing. 2015.

Appendix 1 search strategy

Pubmed database

Concept 1: Heart failure

"Heart failure"[Mesh] OR "heart failure"[tiab] OR "cardiac failure"[tiab] OR "myocardial failure"[tiab] OR "heart decompensation*"[tiab] OR "decompensating heart"[tiab] OR "decompensation of the heart"[tiab] OR "cardiac decompensation*"[tiab] OR "cardiac incompetenc*"[tiab] OR "cardiac insufficienc*"[tiab] OR "cardial decompensation*"[tiab] OR "cardial incompetenc*"[tiab] OR "cardiac incompetenc*"[tiab] OR "cardial insufficienc*"[tiab] OR "heart insufficienc*"[tiab] OR "myocardial insufficienc*"[tiab] OR "myocardial incompetenc*"[tiab] OR "cardiorespiratory failure"[tiab] OR "heart ventricle failure"[tiab] OR "ventricular insufficienc*"[tiab] OR "diastolic dysfunction*"[tiab] OR "heart ventricle overload"[tiab] OR "cardiac ventricle overload"[tiab] OR "cardiac ventricle failure"[tiab] OR "cardiopulmonary insufficienc*"[tiab] OR "cardiopulmonary failure"[tiab] OR "systolic dysfunction*"[tiab] OR "insufficientia cordis"[tiab] OR "heart incompetenc*"[tiab] OR "decompensatio cordis"[tiab] OR "cardio renal syndrome*"[tiab] OR "reno cardiac syndrome*"[tiab] OR "cardiorenal syndrome*"[tiab]

Concept 2: Mobile health

"Telemedicine"[Mesh] OR telemedicine[tiab] OR tele-medicine[tiab] OR "Mobile health"[tiab] OR mHealth[tiab] OR m-health[tiab] OR telehealth[tiab] OR eHealth[tiab] OR e-health[tiab] OR "digital health"[tiab] OR "digital medicine*"[tiab] OR "tele cardiology"[tiab] OR telecardiology[tiab] OR "Mobile Applications"[Mesh] OR "mobile application*" [tiab] OR "mobile app"[tiab] OR "mobile apps"[tiab] OR "portable app"[tiab] OR "portable application*"[tiab] OR "portable apps"[tiab] OR "tablet application*"[tiab] OR "tablet app"[tiab] OR "tablet apps"[tiab] OR "Cell Phone"[Mesh] OR cellphone*[tiab] OR phone*[tiab] OR "mobile telephone*"[tiab] OR Smartphone*[tiab] OR "mobile device*"[tiab] OR tablet*[tiab] OR "Text messaging"[Mesh] OR Text*[tiab] OR "Computers, Handheld"[Mesh] OR computer*[tiab] OR "palm PC"[tiab] OR "Wearable Electronic devices"[Mesh:NoExp] OR wearable*[tiab] OR "wireless communicati*"[tiab] OR "wireless technolog*"[tiab] OR "Fitness Trackers"[Mesh] OR "fitness track*"[tiab] OR "activity track*"[tiab] OR "smart watch*"[tiab] OR "health watch*"[tiab] OR "digital assistant*"[tiab] OR "personal data assistant*"[tiab] OR "Social Media"[Mesh] OR "social media"[tiab] OR youtube[tiab] OR livestream*[tiab] OR twitter[tiab] OR facebook[tiab] OR Instagram[tiab] OR Whatsapp[tiab] OR LinkedIn[tiab] OR "social network*"[tiab] OR "social platform*"[tiab]

Concept 3: exclude conference abstracts and reviews

NOT (review[pt] OR review[ti])

Embase

Concept 1: Heart failure

'heart failure'/de OR 'diastolic dysfunction'/exp OR 'heart ventricle overload'/exp OR 'cardiopulmonary insufficiency'/exp OR 'cardiorenal syndrome'/exp OR 'systolic dysfunction'/exp OR 'heart ventricle failure'/exp OR 'heart failure':ti,ab,kw OR 'cardiac failure':ti,ab,kw OR 'myocardial failure':ti,ab,kw OR 'heart decompensation*':ti,ab,kw OR 'decompensating heart':ti,ab,kw OR 'decompensation of the heart':ti,ab,kw OR 'cardiac decompensation*':ti,ab,kw OR 'cardiac incompetenc*':ti,ab,kw OR 'cardiac insufficienc*':ti,ab,kw OR 'cardial decompensation*':ti,ab,kw OR 'cardial incompetenc*':ti,ab,kw OR 'cardial insufficienc*':ti,ab,kw OR 'heart insufficienc*':ti,ab,kw OR 'myocardial insufficienc*':ti,ab,kw OR 'myocardial incompetenc*':ti,ab,kw OR 'cardiorespiratory failure':ti,ab,kw OR 'ventricular insufficienc*':ti,ab,kw OR 'diastolic dysfunction*':ti,ab,kw OR 'heart ventricle overload':ti,ab,kw OR 'cardiac ventricle overload':ti,ab,kw OR 'cardiac ventricle failure':ti,ab,kw OR 'cardiopulmonary insufficienc*':ti,ab,kw OR 'cardiopulmonary failure':ti,ab,kw OR 'systolic dysfunction*':ti,ab,kw OR 'heart ventricle failure':ti,ab,kw OR 'insufficientia cordis':ti,ab,kw OR 'heart incompetenc*':ti,ab,kw OR 'decompensatio cordis':ti,ab,kw OR 'cardio renal syndrome*':ti,ab,kw OR 'reno cardiac syndrome*':ti,ab,kw OR 'cardiorenal syndrome*':ti,ab,kw

Concept 2: Mobile health

'telemedicine'/de OR 'telecardiology'/exp OR 'mobile application'/exp OR 'mobile phone'/exp OR 'text messaging'/exp OR 'wearable computer'/exp OR 'wireless communication'/exp OR 'personal digital assistant'/exp OR 'social media'/exp OR telemedicine:ti,ab,kw OR tele-medicine:ti,ab,kw OR 'mobile health':ti,ab,kw OR mHealth:ti,ab,kw OR m-health:ti,ab,kw OR telehealth:ti,ab,kw OR eHealth:ti,ab,kw OR e-health:ti,ab,kw OR 'digital health':ti,ab,kw OR 'digital medicine*':ti,ab,kw OR 'tele cardiology':ti,ab,kw OR telecardiology:ti,ab,kw OR 'mobile application*':ti,ab,kw OR 'mobile app':ti,ab,kw OR 'mobile apps':ti,ab,kw OR 'portable app':ti,ab,kw OR 'portable application*':ti,ab,kw OR 'portable apps':ti,ab,kw OR 'tablet application*':ti,ab,kw OR 'tablet app':ti,ab,kw OR 'tablet apps':ti,ab,kw OR cellphone*:ti,ab,kw OR phone*:ti,ab,kw OR 'mobile telephone*':ti,ab,kw OR smartphone*:ti,ab,kw OR 'mobile device*':ti,ab,kw OR tablet*:ti,ab,kw OR 'text messag*':ti,ab,kw OR text*:ti,ab,kw OR computer*:ti,ab,kw OR 'palm PC':ti,ab,kw OR wearable*:ti,ab,kw OR 'wireless communicati*':ti,ab,kw OR 'wireless technolog*':ti,ab,kw OR 'fitness track*':ti,ab,kw OR 'activity track*':ti,ab,kw OR 'smart watch*':ti,ab,kw OR 'health watch*':ti,ab,kw OR 'digital assistant*':ti,ab,kw OR 'personal data assistant*':ti,ab,kw OR 'social media':ti,ab,kw OR youtube:ti,ab,kw OR livestream*:ti,ab,kw OR twitter:ti,ab,kw OR facebook:ti,ab,kw OR Instagram:ti,ab,kw OR Whatsapp:ti,ab,kw OR LinkedIn:ti,ab,kw OR 'social network*':ti,ab,kw OR 'social platform*':ti,ab,kw

Concept 3: exclude conference abstracts and reviews

NOT (review:ti OR review:it OR 'conference abstract':it)

Web of Science Core Collection
Indices used:

Science Citation Index Expanded

(SCI-EXPANDED)—1955-present

Social Sciences Citation Index

(SSCI)—1956-present

Arts & Humanities Citation Index

(AHCI)—1975-present

Emerging Sources Citation Index

(ESCI)—2005-present

Concept 1: Heart failure

TS=("heart failure" OR "cardiac failure" OR "myocardial failure" OR "heart decompensation*" OR "decompensating heart" OR "decompensation of the heart" OR "cardiac decompensation*" OR "cardiac incompetenc*" OR "cardiac insufficienc*" OR "cardial decompensation*" OR "cardial incompetenc*" OR "cardial insufficienc*" OR "heart insufficienc*" OR "myocardial insufficienc*" OR "myocardial incompetenc*" OR "cardiorespiratory failure" OR "heart ventricle failure" OR "ventricular insufficienc*" OR "diastolic dysfunction*" OR "heart ventricle overload" OR "cardiac ventricle overload" OR "cardiac ventricle failure" OR "cardiopulmonary insufficienc*" OR "cardiopulmonary failure" OR "systolic dysfunction*" OR "insufficientia cordis" OR "heart incompetenc*" OR "decompensatio cordis" OR "cardio renal syndrome*" OR "reno cardiac syndrome*" OR "cardiorenal syndrome*")

Concept 2: Mobile health

TS=(telemedicine OR "tele medicine" OR "mobile health" OR mHealth OR m-health OR telehealth OR eHealth OR e-health OR "digital health" OR "digital medicine*" OR "tele cardiology" OR telecardiology OR "mobile application*" OR "mobile app" OR "mobile apps" OR "portable app" OR "portable application*" OR "portable apps" OR "tablet application*" OR "tablet app" OR "tablet apps" OR cellphone* OR phone* OR "mobile telephone*" OR smartphone* OR "mobile device*" OR tablet* OR "text messag*" OR text* OR computer* OR "palm PC" OR wearable* OR "wireless communicati*" OR "wireless technolog*" OR "fitness track*" OR "activity tracker*" OR "smart watch*" OR "health watch*" OR "digital assistant*" OR "personal data assistant*" OR "social media" OR youtube OR livestream* OR twitter OR facebook OR Instagram OR Whatsapp OR LinkedI OR "social network*" OR "social platform*")

Concept 3: exclude conference abstracts and reviews

NOT (DT=("meeting abstract" OR "review" OR "editorial material") OR TI=("review"))

Cochrane CENTRAL

Concept 1: Heart failure

[mh “Heart failure”]

(“heart failure” OR “cardiac failure” OR “myocardial failure” OR (heart NEXT decompensation*) OR “decompensating heart” OR “decompensation of the heart” OR (cardiac NEXT decompensation*) OR (cardiac NEXT incompetenc*) OR (cardiac NEXT insufficienc*) OR (cardial NEXT decompensation*) OR (cardial NEXT insufficienc*) OR (heart NEXT insufficienc*) OR (myocardial NEXT insufficienc*) OR (myocardial NEXT incompetenc*) OR “cardiorespiratory failure” OR “heart ventricle failure” OR (ventricular NEXT insufficienc*) OR “diastolic dysfunction” OR “heart ventricle overload” OR “cardiac ventricle overload” OR “cardiac ventricle failure” OR (cardiopulmonary NEXT insufficienc*) OR “cardiopulmonary failure” OR (systolic NEXT dysfunction*) OR “insufficientia cordis” OR (heart NEXT incompetenc*) OR “decompensatio cordis” OR (cardio NEXT renal NEXT syndrome*) OR (reno NEXT cardiac NEXT syndrome*) OR (cardiorenal NEXT syndrome*)):ti,ab,kw

Concept 2: Mobile Health

[mh “Telemedicine”] OR [mh “Mobile Applications”] OR [mh “Computers, handheld”] OR [mh ^”Wearable Electronic devices”] OR [mh “Text Message”] OR [mh “Fitness Trackers”] OR [mh “Cell Phone”] OR [mh “Social Media”]

(telemedicine OR tele-medicine OR “mobile health” OR mhealth OR m-health OR telehealth OR ehealth OR e-health OR “digital health” OR (digital NEXT medicine*) OR “tele cardiology” OR telecardiology OR (mobile NEXT application*) OR “mobile app” OR “mobile apps“ OR “portable app” OR (portable NEXT application*) OR “portable apps” OR (tablet NEXT application*) OR “tablet app” OR “tablet apps” OR cellphone* OR phone* OR (mobile NEXT telephone*) OR smartphone* OR (mobile NEXT device*) OR tablet OR (text NEXT messag*) OR text* OR computer* OR “palm PC” OR wearable* OR (wireless NEXT communication*) OR (wireless NEXT communicate*) OR (wireless NEXT technolog*) OR (fitness NEXT tracker*) OR (activity NEXT track*) OR (smart NEXT watch*) OR (health NEXT watch*) OR (digital NEXT assistant*) OR (personal NEXT data NEXT assistant*) OR “social media” OR youtube OR livestream* OR twitter OR facebook OR Instagram OR whatsapp OR linkedin OR (social NEXT network*) OR (social NEXT platform*)):ti,ab,kw

CINAHL via EBSCO

Concept 1: Heart failure

(MH "Heart Failure") OR TI (“heart failure” OR “cardiac failure” OR “myocardial failure” OR “heart decompensation*” OR “decompensating heart” OR “decompensation of the heart” OR “cardiac decompensation*” OR “cardiac incompetenc*” OR “cardiac insufficienc*” OR “cardial decompensation*” OR “cardial incompetenc*” OR “cardial insufficienc*” OR “heart insufficienc*” OR “myocardial insufficienc*” OR “myocardial incompetenc*” OR “cardiorespiratory failure”[tiab] OR "heart ventricle failure” OR “ventricular insufficienc*” OR “diastolic dysfunction*” OR “heart ventricle overload” OR “cardiac ventricle overload” OR “cardiac ventricle failure” OR “cardiopulmonary insufficienc*” OR “cardiopulmonary failure” OR “systolic dysfunction*” OR “insufficientia cordis” OR “heart incompetenc*” OR “decompensatio cordis” OR “cardio renal syndrome*” OR “reno cardiac syndrome*” OR “cardiorenal syndrome*”) **OR AB** (“heart failure” OR “cardiac failure” OR “myocardial failure” OR “heart decompensation*” OR “decompensating heart” OR “decompensation of the heart” OR “cardiac decompensation*” OR “cardiac incompetenc*” OR “cardiac insufficienc*” OR “cardial decompensation*” OR “cardial incompetenc*” OR “cardial insufficienc*” OR “heart insufficienc*” OR “myocardial insufficienc*” OR “myocardial incompetenc*” OR “cardiorespiratory failure”[tiab] OR "heart ventricle failure” OR “ventricular insufficienc*” OR “diastolic dysfunction*” OR “heart ventricle overload” OR “cardiac ventricle overload” OR “cardiac ventricle failure” OR “cardiopulmonary insufficiency” OR “cardiopulmonary failure” OR “systolic dysfunction*” OR “insufficientia cordis” OR “heart incompetenc*” OR “decompensatio cordis” OR “cardio renal syndrome*” OR “reno cardiac syndrome*” OR “cardiorenal syndrome*”)

Concept 2: Mobile health

(MH "Telehealth+") OR (MH "Telephone+") OR (MH "Wireless Communications") OR (MH "Social Media+") OR TI (telemedicine OR tele-medicine OR “Mobile health” OR mHealth OR m-health OR telehealth OR eHealth OR e-health OR “digital health” OR “digital medicine*” OR “tele cardiology” OR telecardiology OR “mobile application*” OR “mobile app” OR “mobile apps” OR “portable app” OR “portable application*” OR “portable apps” OR “tablet application*” OR “tablet app” OR “tablet apps” OR cellphone* OR phone* OR “mobile telephone*” OR Smartphone* OR “mobile device*” OR tablet* OR Text* OR computer* OR “palm PC” OR wearable* OR “wireless communicati*” OR “wireless technolog*” OR “fitness track*” OR “activity track*” OR “smart watch*” OR “health watch*” OR “digital assistant*” OR “personal data assistant*” OR “social media” OR youtube OR livestream* OR twitter OR facebook OR Instagram OR Whatsapp OR LinkedIn OR “social network*” OR “social platform*”) **OR AB** (telemedicine OR tele-medicine OR “Mobile health” OR mHealth OR m-health OR telehealth OR eHealth OR e-health OR “digital health” OR “digital medicine*” OR “tele cardiology” OR telecardiology OR “mobile application*” OR “mobile app” OR “mobile apps” OR “portable app” OR “portable application*” OR “portable apps” OR “tablet application*” OR “tablet app” OR “tablet apps” OR cellphone* OR phone* OR “mobile telephone*” OR Smartphone* OR “mobile device*” OR tablet* OR Text* OR computer* OR “palm PC” OR wearable* OR “wireless communicati*” OR “wireless technolog*” OR “fitness track*” OR “activity track*” OR “smart watch*” OR “health watch*” OR “digital assistant*” OR “personal data assistant*” OR “social media” OR youtube OR livestream* OR twitter OR facebook OR Instagram OR Whatsapp OR LinkedIn OR “social network*” OR “social platform*”)

Appendix 2: Inclusion and exclusion criteria

Inclusion criteria:

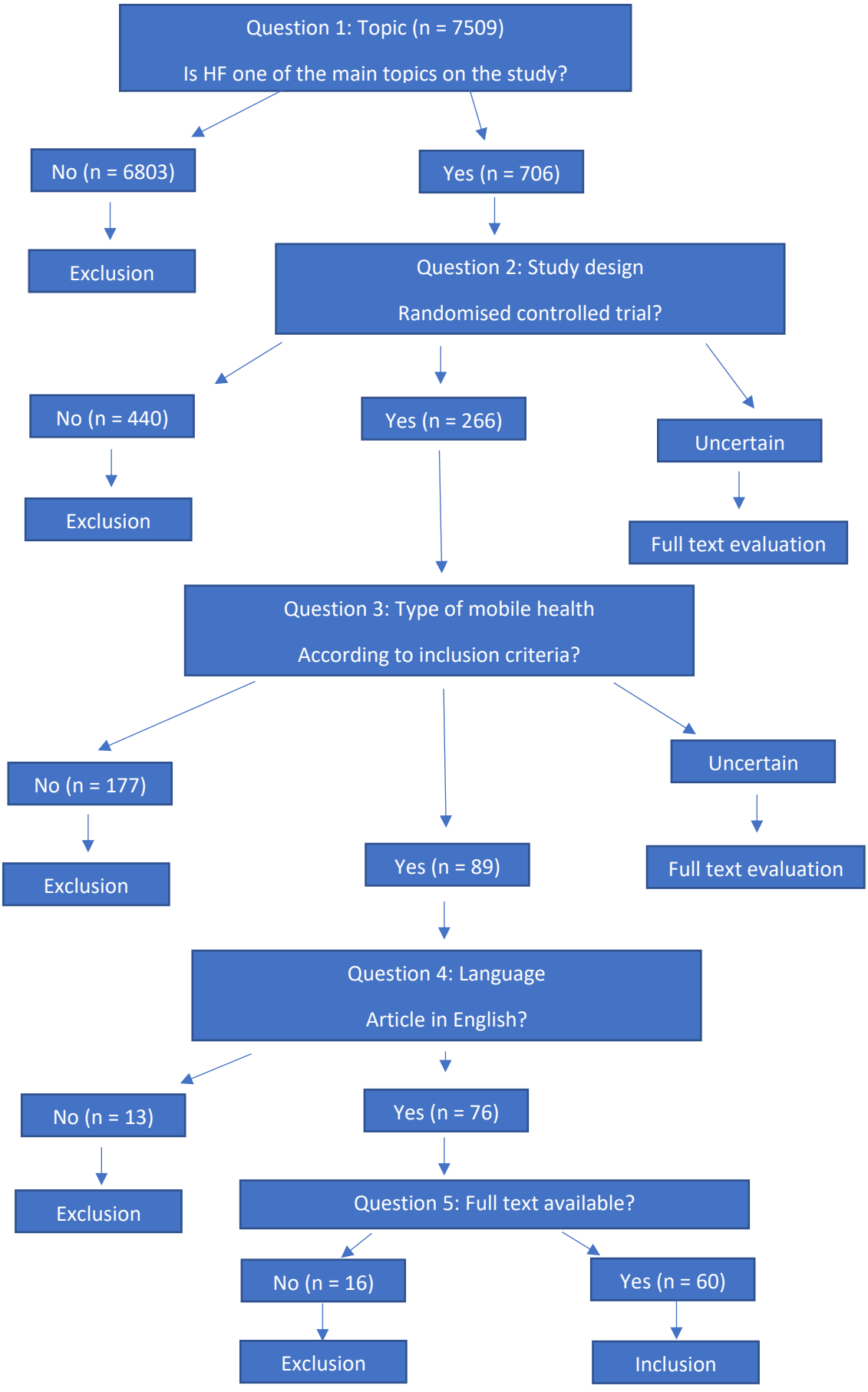
- Adult patients (18 years and older) with chronic heart failure disease (HFrEF, HFpEF, HFmrEF) and their caregiver
- Articles in English or articles of which an English translation exists
- Articles published from January 2010 to December 2022
- Randomized controlled trials
- Digital interventions that include:
    - Stimulation of patient adherence to treatment and supporting recovery
    - Online education programs to develop skills
    - The use of biometric sensors (weight, saturation, heartrate) to improve patient self-care, such as iomedication alteration, emergency care visits at the appropriate time
    - Mobile apps, SMS messages, wearables, social media and interactive websites which improve health by supporting behavioural change of patients and teach new skills
    - Digital interventions which lead to active patient engagement
    - SMS messages who reminds patients to practice selfcare, messages with the aim of achieving treatment compliance and disease management
    - community mobilization and health promotion (the use of text messaging for health promotion or to alert target groups of health campaigns)
    - Information access: services that provide access to health science publications or databases at point of care using mobile devices (information aimed at patients, not at doctors)
    - Health awareness rising, the use of health information products, games or quiz programs to educate people on health topics (these programs can often be downloaded onto the mobile phone or as a series of text messages that tell a story with embedded health messages)

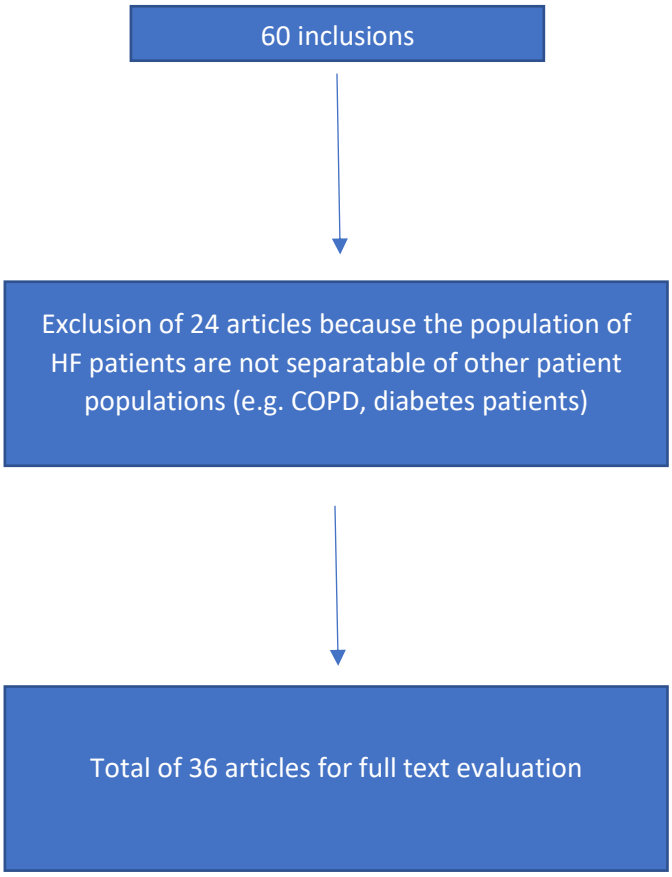
Exclusion criteria:

- Case reports and case series
- Feasability studies
- Systematic reviews
- Observational studies
- Narrative reviews
- Telemonitoring
- Unpublished studies
- Digital interventions which include:
    - Text messages just to remind the patient of the appointment, or the schedule an appointment, or messages concerning treatment results
    - Teleconsultations with a licensed practitioner or educator
    - Education programs for healthcare professionals
    - The use of electronic medical systems by healthcare professionals (EMD), mobile patient records used to support clinicians by treating the patients
    - The use of biometric sensors as a form of telemonitoring, without active involvement of the patient in the health care process. Remote sensors installed in households or imaging devices linked to mobile phones are often used to facilitate data transmission to the health service provider
    - Devices where no digital code is available or where no mobile literacy is needed, such as watching a DVD or a television show
    - Online therapeutic or coaching sessions where the patient only participates passively
    - Remote communication devices offering communication by telephone or video between patient and clinicians (the patient only participates passively); for example Skype, FaceTime
    - GPS tracking for cognitive impaired patients
    - Pendant alarms
    - Health call centers (a service created to deliver health care advice triage services by trained health professionals on the telephone)
    - Emergency toll-free telephone service, often used for quick access to health professionals or staff trained to provide direction during a medical emergency
    - Managing emergencies and disasters (the use of mobile devices to respond to and manage emergency and disaster situations such as natural disasters, disease outbreaks)
    - Health surveys in the context of mHealth (the use of mobile devices for health-related data collection and reporting) and surveillance (the use of mobile devices to input and transmit data that will be used to track diseases for surveillance programs
    - Decision support systems (software algorithms that advise health providers on clinical diagnoses of patients based on the interaction of patient data and medical information)
    - Artificial intelligence (the general term for imitating human intelligence with computer systems) and deep learning
    - Messages which are untargeted and undifferentiated, when an audience receives identical messages

- Client to client communication (self-help groups)

Appendix 3: Flowchart: Selection of studies based on title and abstract




60 inclusions
Exclusion of 24 articles because the population of HF patients are not separatable of other patient populations (e.g. COPD, diabetes patients)
Total of 36 articles for full text evaluation

Appendix 4: Risk bias assessment results and GRADE quality rating

	1. Random sequence generation (selection bais)	2. Allocation concealment (selection bias)	3. Blinding of participants and personnel (performance bias)	4. Blinding of outcome assessment (detection bias)	5. Incomplete outcome data (attrition bias)	6. Selective reporting (reporting bias)	7. Group similarity at baseline (selection bias)	8. Co-interventions (performance bias)	9. Compliance (performance bias)	10. Intention-to-treat-analysis	11. Timing of outcome assessments (detection bias)	12. Other bias	**Quality rating***	**Comment**
Dorsch et al.	+	+	-	-	+	+	-	+	+	+	+	+	Moderate	
Chen et al.	+	+	-	-	+	+	+	+	+	+	+	+	Moderate	
Jiang et al.	+	+	-	-	+	+	+	+	+	+	+	+	Moderate	
Wonngom et al.	+	+	-	-	+	+	+	+	+	+	+	+	Moderate	
Yanicelli et al.	+	+	-	-	+	+	+	+	+	+	+	+	Moderate	
Wang et al.	?	?	-	-	?	+	+	?	?	+	+	?	Low	Exclusion
Wagenaar et al.	+	+	-	-	+	+	+	-	?	+	+	+	Moderate	
Sahlin et al.	+	+	-	-	+	+	+	+	+	+	+	+	Moderate	
Nolan et al.	+	+	+	+	+	+	+	-	+	+	+	+	High	
Hagglund et al	+	+	-	-	+	+	+	+	+	+	+	-	Moderate	
Melin et al.	+	+	-	-	+	+	+	+	+	+	+	-	Moderate	
Kiyarosta et al.	+	+	-	-	+	+	+	+	+	+	+	+	Moderate	
Somsiri et al.	+	+	-	-	+	-	+	+	+	+	+	+	Moderate	

+ means low risk of bias, - means high risk of bias, ? means unknown risk of bias

**Questions that were given more weight by the reviewers where number 1, 2, 6 and 8. Questions 3 and 4 were given less weight given the fact that most studies suffer from some sort of Hawthorne effect, as most intervention groups are not fully blinded. If double blinding was guaranteed (Nolan et al.), this was considered as an higher quality article.*

Reflectieverslag – LENS, Laura

Deze thesis schreef ik met 2 collega HAIO's Arne en Lauren, tevens 2 van mijn goede vrienden. We wisten van het begin al dat we allemaal harde werkers zijn en durven elkaar ook eerlijke feedback te geven, dit maakte het samenwerken zeer aangenaam. De start van de thesis verliep stroef, maar eens alle artikels geselecteerd waren en het interessante schrijfwerk kon beginnen, liep alles zeer vlotjes. Het opstellen van de zoekstrategie heeft wat zweet en tranen gekost, dit was geen gemakkelijk en ook geen plezierig werk voor ons topic. Initieel hebben we elkaar veel moeten motiveren om te starten aan de masterthesis, voornamelijk het screenen van de 8000 artikels was een tijdsrovend werk. . We hebben ons doorheen de artikelselectie gesleept, want dit was veel werk met initieel weinig zichtbaar resultaat. Ik heb op deze momenten echt mijn team nodig gehad om ons erdoor te helpen. We deden dit elk apart en geblindeerd via Rayyan, dus voor dit deel was het even allen voor zich waarin ik wel merkte dat ik echt de motivatie van Arne en Lauren nodig had. Het gebruik van de Rayyan website voor artikelselectie is wel een van de beste tips die we van de bibliotheek van Leuven (leercentrum Desiré Collen) hebben gekregen, dit maakte het heel erg overzichtelijk en nadien ook makkelijk om onderling de discussie aan te gaan voor artikel selectie. Eens door deze grote boterham, begon het interessante werk. In de tweede fase van onze opleiding liep het vlotter en waren we meer gestimuleerd om aan onze thesis te werken. Onze co-promotor heeft ons toen elke keren via zoom sessies heel nuttige feedback gegeven en samen met ons een werkschema opgesteld.

Het is een leuke ervaring om met 3 een thesis te schrijven, ieder heeft sterke en zwakke kanten. Er zijn nooit discussies geweest waar we niet uit geraakte. Ook de communicatie met onze co-promotor, Miek, verliep heel erg vlot en ze stond altijd meteen klaar voor feedback en hulp. We hebben elkaar goed aangevuld en samen een mooi werk afgeleverd waar we trots op zijn. Algemeen heeft iedereen evenveel aandeel in de thesis. Voor een vlot verloop werden sommige taken wel verdeeld. Lauren was zo bijvoorbeeld de verantwoordelijke voor communicatie met de (co)promotor en de bibliotheek, zij is zeer punctueel en ordelijk, waardoor dit allemaal vlot verliep. Dit hield in dat ze de e-mails opstelden, onze vragen en to-do lijst bijhield en verslagen maakte van onze overleggen. Verder las ze ook ettelijke

keren de thesis door en na op schoonheidsfoutjes. Arne was de verantwoordelijke voor de bronnen van de thesis, we hebben ervoor gekozen dat dit door één iemand gedaan werd zodat hier zeker geen fouten in slopen. Ikzelf heb de artikels gezocht achter de geselecteerde teksten en de vergelijkende studie gemaakt met andere systematic reviews rond dit topic. Verder hebben we allemaal een gelijk aandeel in het schrijven van de masterthesis, we hebben elkaar echt mooi aangevuld en ik ben tevreden over onze samenwerking. We hebben tijdens dit werk veel geleerd en moeten heropfrissen, zoals de richtlijnen over methodiek en hoe we een goede systematic review moeten maken.

Ik heb veel geleerd uit deze thesis en het nut van mobile health voor chronische ziekten zoals hartfalen. Helaas lijkt dit nog een ver van ons bed show, aangezien er nog veel tekorten zijn in de onderzoeken. Momenteel lijkt de huidige doelgroep van hartfalen die we eerste lijn opvolgen ge-excludeerd in alle studies omwille van cognitieve beperkingen. Verder is er geen universele applicatie die gebruikt wordt en ook geen zicht op lange termijn gebruik. Deze lacunes moeten in toekomstige klinische trails opgepakt worden.

In de huidige samenleving, waar iedereen rondloopt met een telefoon in de hand is m-health zeker toepasbaar in de eerstelijnszorg. Het kan door juist toe te passen een belangrijke impact hebben op patiënten hun ziekteinzicht en zelfzorg. Binnen de chronische ziekte hartfalen, zal dit eerder toekomst gericht zijn in mijn ogen dan nu al toepasselijk. De doelgroep momenteel behoort tot de leeftijdscategorie die niet zo handig is met de huidige technologie, waardoor hun motivatie tot routinematig van applicaties (wat een belangrijke voorwaarde is) snel zal wegebben. Enkele voorwaarden voor het opnemen van mobile health bij hartfalen in de eerste lijn is zeker een universele app die gekend is onder de eerstelijn en snel uploadbaar is in ieder elektronisch medisch dossier (het is niet de bedoeling dat dit meer administratief werk wordt voor de arts) en focus op educatie rond het gebruik van m-health voor de patiënt of voor de mantelzorger in geval van oudere leeftijd.
Verder moet zorg voor de patiënt wel nog persoonlijk gericht blijven en mag dit niet te hevig digitaliseren. Regelmatige controle via eerstelijnszorg blijft belangrijk en kan niet worden vervangen

door een applicatie, maar het biedt wel een mooie ondersteuning in de zorg. Ik denk dat het ook goed toepasbaar zou kunnen zijn om op deze manier de tekorten in de patiënten hun ziektekennis aan te vullen en ieder consult eens samen te overlopen wat ze geleerd hebben.

Reflectieverslag – OOSTERBOS, Lauren

Voor mijn masterthesis werkte ik samen met twee andere HAIO's, Laura Lens en Arne Vrysen. Ik heb onze samenwerking als heel aangenaam en leerrijk ervaren. We vulden elkaar goed aan als een team. In de eerste jaren van onze opleiding huisartsgeneeskunde durfden we onze masterpaper al eens te laten liggen waardoor we wat achterop geraakten. Met behulp van onze co-promotor stelden we in ons tweede jaar een duidelijke planning met haalbare deadlines op. Als team stimuleerden we elkaar tot het halen van deze deadlines, waardoor we onze planning uiteindelijk wel goed konden volgen. Waar de een minder goed in was, was de ander weer sterker in. Zo tilden we samen onze thesis naar een hoger niveau. We hebben samen veel werk verzet, onder andere meer dan 8000 artikels gescreend, en dit is een grote sterkte van onze thesis. Bovendien heb ik van hen veel bijgeleerd, gaande van het aanpakken van de bronnen, lay-out, werking van excel, tot hun praktijkervaringen over hartfalen.

Tijdens het schrijven van onze thesis heb ik vooral de rol van communicator tussen ons en de (co-)promotor(en) op mij genomen. Hieronder viel onder andere het opstellen van de mails en het formuleren van onze vragen. Ik hield me ook bezig met het bijhouden van verslagen van onze meetings met de (co-)promotor(en) en het maken van to-do-lijstjes om hetgeen we moesten doen overzichtelijk te houden. Ik ben van nature perfectionistisch ingesteld en hier kwam dit goed van pas. We schreven allemaal samen aan alle onderdelen van onze thesis en vulden elkaar op dit vlak ook opnieuw goed aan. Het was voor ons drie samen een zoektocht naar hoe we de systematic review methodologisch moesten uitvoeren en dit is voor mij niet mijn sterkste kant. Met behulp van onze co-promotoren en mijn groepsleden is dit wel goed gelukt en hebben we onze systematic review volgens de regels en gestructureerd uitgevoerd.

Door ons opzoekwerk ben ik enerzijds meer te weten gekomen over wat hartfalen educatie en zelfzorg allemaal inhoudt, en anderzijds over de technologische evolutie die er gaande is binnen de gezondheidszorg. In mijn ogen toont ons werk aan dat er nog grote evoluties te verwachten zijn binnen

de mobile health en de geneeskunde op vlak van hartfalen, maar ook in de geneeskunde algemeen. Onze studie toonde heel wat knelpunten die misschien niet allemaal even gemakkelijk te verhelpen zijn, maar ook veel belovende resultaten van het gebruik van mobiele apps door patiënten. Ik geloof ook dat als de huidige volwassen populatie binnen jaren tot de geriatrische populatie zal horen, deze groep mensen ook al veel vlotter zal kunnen omspringen met technologie en apps. Dit omdat dit veel meer tot hun leefwereld behoort dan de huidige groep ouderen. Hierdoor zal al een grote drempel overwonnen zijn. Een andere moeilijke drempel zal het gebruik van deze technologie bij patiënten met geheugenproblematiek zijn. Een oplossing hiervoor kan zijn dat de mantelzorger deze functie volledig overneemt, of dat de thuisverpleging van de patiënt de registraties via de app kan doen. Het onderwijzen van iemand met geheugenproblemen is minder goed mogelijk, maar via derden kan deze rol wel worden overgenomen.

Als huisarts heb je een belangrijke rol in het onderwijzen van patiënten over hun aandoeningen en is het een cruciaal onderdeel van je taak om de patiënt te wijzen op therapietrouwheid. Hartfalen is een complexe aandoening die beter onder controle gehouden kan worden als de patiënt meer inzicht heeft in zijn of haar ziekte. Mobiele apps en andere mobiele interventies kunnen de huisarts bijstaan in zijn taak tot educatie van de patiënt en hierdoor wat workload van de huisarts wegnemen. Tevens kan er samen met de patiënt bepaalde cut-off waarden besproken worden, waardoor de patiënt die zijn parameters opvolgt, weet wanneer hij of zij best zijn of haar huisarts contacteert. De huisarts zal hier steeds slechts een deel van het team uitmaken, samen met een eventuele verpleegkundige en de cardioloog. Op dit moment loopt de communicatie tussen patiënten met hartfalen die gebruik maken van mHealth meestal via hartfalenverpleegkundigen. Dit zou bijvoorbeeld geïntegreerd kunnen worden met het globaal medisch dossier dat de patiënt bij zijn of haar huisarts heeft. Hierdoor kan de eerste lijn meer up-to-date betrokken geraken bij de zorg. Ik denk dat vooraleer dit kan gebeuren er misschien een meer universele app gebruikt moet worden, want in de huidige literatuur werden er veel verschillende vormen van mHealth gebruikt die allen wel wat van elkaar verschilden. Toekomstig onderzoek zal hier ook in helpen.

Door het schrijven van deze masterpaper zal ik als toekomstig huisarts meer oog hebben voor de educatie van patiënten met hartfalen, omdat ik nu ook meer weet welke impact dit heeft op ziekenhuisopnames, therapietrouw, kwaliteit van leven,… Indien patiënten werken via een app die verbonden is met het ziekenhuis, zal ik mij ook meer vertrouwd voelen om hiermee om te gaan. Over een aantal jaren zal het gebruik van deze mobiele apps vermoedelijk meer uitgerold zijn en is er misschien ook een meer prominente plaats voor de huisarts zelf, en deze al zal ik dan met veel plezier innemen.

Reflectieverslag – VRYSEN, Arne

Er zijn meerdere factoren die het groepsproces gemaakt hebben tot wat het uiteindelijk geworden is. Allereerst kende ik mijn twee mede-haio's, Laura en Lauren, reeds meerdere jaren en zijn we goed bevriend. Dit maakte de initiële samenwerking zeker gemakkelijker, we waren immers vertrouwd met elkaar. Ik wist ook dat we allemaal harde werkers waren, die elkaar zouden helpen waar nodig, maar elkaar ook zouden aanmanen opdat iedereen zijn steentje zou bijdragen. Het zorgde tevens voor een organisch verloop met regelmatig contact en updates van het geleverde werk.

Initieel waren we vol goede moed vertrokken, met een duidelijke visie voor ogen. Het opstellen van de methode sectie verliep algemeen vrij vlot. Het moeilijkere deel was het opstellen van een geschikte zoekstrategie, hier is wel redelijk wat tijd in gekropen. Ook het doorlopen van alle gevonden bronnen met deze zoekstrategie verliep moeizaam. Hierdoor verloren we op bepaalde momenten wel wat motivatie. Desalniettemin voelde ik me gesteund en gemotiveerd door mijn collega's. Dit stuk had achteraf bekeken sneller kunnen gaan. De grote hoeveelheid aan bronnen waar we door zijn moeten gaan (> 8000 bronnen) had echter een vrij verlammend effect. Nadat deze drempel overwonnen was, zaten we wel wat achter op schema. In samenspraak met onze co-promotor, Miek, werd er een vrij strak schema opgesteld om deze verloren tijd in te halen. Iedereen heeft volgens mij zijn/haar steentje bijgedragen om dit te doen slagen. We hebben altijd open met elkander kunnen communiceren over bezorgdheden en frustraties. Anderzijds konden we elkaar ook zeker positief benaderen door middel van complimentjes en aanmoedigingen. Deze gemoedelijke en efficiëntie bevorderende groepssfeer is de voornaamste pluim die ik aan ons groepsproces zou willen toekennen. Ondanks persoonlijke tegenslagen, drukke agenda's, werkdruk en ziekte hebben we elkaar blijven ondersteunen en motiveren.

Het persoonlijke aandeel van de master thesis is daarom ook vrij moeilijk af te lijnen. Het enige deel waarvan ik kan zeggen dat ik het volledig alleen gedaan heb is het invoegen van de bronnen met een referentiemanager. Dit was niet uit onwil van de mede-haio's, maar vooral gedaan vanuit een praktisch

standpunt en met voorbedachten rade. De rest van de master thesis is vrij organisch gegroeid. We hebben ieder in elk deel van de thesis tijd en moeite gestoken. We zijn dan ook zeer vaak, vooral naar het einde toe, samen gekomen om onze bevindingen op een uniforme manier te beschrijven. Elk lid van de groep heeft zijn aandeel gedaan bij zowel het vooraf nadenken over het precieze onderwerp, het uitwerken van de methodes, het uitvoeren van de zoekstrategie, het includeren en excluderen van de gevonden bronnen, het maken van de tabellen/flowchart, Het schrijven van de inleiding, resultaten en discussie en het opmaken van het document. Desalniettemin zijn er natuurlijk verschillen geweest in hoeveel iemand aan elk bepaald stuk geschreven heeft. Zo heeft Lauren vooral de communicatie naar de promotor verzorgd, alsook de prisma flowchart gemaakt. Lauren en ik hebben ons voornamelijk bezig gehouden met de figuren uit de resultaten. Laura heeft dan weer meer tijd gestoken in het vinden van goede bronnen en systematic reviews om onze resultaten en discussie te kunnen staven en te vergelijken met anderen. Er zijn nog tal van andere voorbeelden waar de ene persoon wat meer aan heeft gewerkt dan de andere, maar algemeen gezien heb ik het gevoel dat het werk evenredig verdeeld was.

Ik heb tevens genoopt om op andere vlakken goed samen te werken en een aangename sfeer te vormen, om een luisterend oor te bieden of een klop op de schouder te geven aan wie het nodig had. Ik hoop dat ik me als toekomstige huisarts gedragen heb, met professionaliteit, communicator, samenwerker en de andere CanMEDS rollen hoog in het vaandel.

Wat mijn persoonlijke visie betreft over de werkelijke betekenis en implicaties voor het werkveld van onze thesis, moet ik me aansluiten bij wat vermeld wordt in onze discussie. Ik kan stellen dat Mobile Health in mijn ogen zeker een gegeven van de nabije toekomst gaat worden en uitstekend toepasbaar is binnen hartfalen. De laatste jaren zijn er steeds meer studies verschenen over dit onderwerp. Tot dusverre zijn dit voornamelijk studies uitgevoerd in samenwerking met ziekenhuizen. Er zijn weinig tot geen studies gebeurd binnen huisartsenpraktijken. Wat er in huidig onderzoek mist is uniformiteit van de verschillende applicaties, maar ook in de uniformiteit van de wijze waarop de resultaten gemeten

worden. Dit samen met de relatief beperkte subgroep van hartfalen patiënten die geïncludeerd werden door de strikte inclusie- en exclusiecriteria, alsook de relatief beperkte follow-up tijden zorgden ervoor dat er helaas weinig overtuigende conclusies getrokken kunnen worden uit onze studie. Het positieve hiervan is dat er wel een duidelijk hiaat aangetoond wordt en dat moet aangespoord worden om heir verder onderzoek in te verrichten.

Mijn verder persoonlijke visie is vooral gericht op de toepasbaarheid van deze technologieën in de huidige huisartsenpraktijk. Moesten deze applicaties op punt gesteld worden en het positief effect definitief aangetoond worden, dan zouden ze een grote positieve impact kunnen hebben op de chronische zorg van mensen met hartfalen. Het zou ook de taak van de huisarts kunnen verlichten/ondersteunen. Desalniettemin moeten we als huisarts bedacht blijven voor eventuele "blinde vlekken". Een kanttekening die volgens mij moet gemaakt worden, is dat deze patiënten populatie vaak co-morbiditeit heeft en dat het over het algemeen fragielere patiënten betreft. Blijvende hands-on zorg is dus zeker nodig en valabel. Persoonlijk zie ik mobile health dus als een manier om de patiënt geëngageerd en geïnformeerd te krijgen met zijn ziekte. Het is een bijkomende mogelijkheid in een hele reeks van ondersteunende therapieën. Persoonlijke, patiëntgerichte zorg blijft de hoeksteen van huisartsenzorg.