Impact of Remote Telehealth on Patients with Heart Failure: A Meta-Analysis

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IMPACT OF REMOTE TELEHEALTH ON PATIENTS WITH HEART FAILURE

Abstract

Aims: The use of telehealth for heart failure management is increasing and it is not clear from the literature whether it is more beneficial than usual care. A meta-analysis was done of published randomized controlled trials to compare telehealth management and usual physician care for heart failure patients. The primary outcomes studied include mortality, hospital readmissions and quality of life.

Methods: A systematic search was done to identify trials that met the inclusion criteria. To be included a study had to be a randomized controlled trial published in English with all participants diagnosed with heart failure. Studies had to compare usual care to telehealth with at least one of the outcomes in this analysis. Data was extracted and classified using the AHA taxonomy for disease management and RevMan 5.3 was used for the data analysis. All outcomes were calculated using random effects models and the quality of life outcome used the mean difference.

Results: 1548 studies were screened against the above inclusion and exclusion criteria. This resulted in 8 randomized controlled trials being selected for meta-analysis with individual comparisons for each outcome studied. Telehealth interventions showed no significant benefits over usual care for all main outcomes. All-cause mortality (p=0.38, 95% CI 0.69-1.16), heart failure related hospitalizations (p=0.67, 95% CI 0.76-1.20), all-cause rehospitalization (p=0.76, 95% CI 0.96-1.10) and quality of life (p=0.78, 95% CI -6.59 to -4.94).

Conclusions: Current telehealth based interventions for HF self-care show no benefit over usual care.

Keywords: Heart failure, telehealth, usual care, morbidity, mortality, quality of life, readmission.

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Introduction

Heart failure (HF) is a syndrome that develops when the heart can no longer effectively pump blood to meet the demands of the body (Ponikowski et el. 2014). HF develops secondary to an initial insult usually caused by an ischemic injury or complications from comorbid disease that results in decreased heart function (Heart and Stroke Foundation of Canada, 2013). HF rates are rising around the world with approximately 26 million people living with the condition worldwide (Ponikowski et al. 2014). Currently, there are many treatment options available for HF management such as medications, self-care, and physician follow up. There are also more complex programs that utilize a cardiologist and a multidisciplinary team to promote medication compliance, effective self-care and ongoing patient support. These program types are diverse and include: facility-based rehabilitation, home care interventions and remote monitoring that utilize advanced technology programs like telemonitoring (TM) and telehealth (TH) (Creaser et al., 2015).

With advances in technology and telecommunications TM and TH interventions are an increasingly common means to promote effective disease management in patients who live with chronic diseases such as HF (Lu, Chi, & Chen, 2014). Technology is advancing at a rapid rate and its' applicability for healthcare and remote monitoring programs is a reality. HF can affect people from any age group; however, the majority of HF patients are over the age of 65 (Bui, Horwich, & Fonarow, 2011). This age group has unique needs that require consideration when diagnosed with HF, particularly around TM and TH usage. Many patients and spouses/caregivers do not understand the complexity of the HF disease process and the comprehensive monitoring and management that is required to prevent negative outcomes (Clark, Morrison, Capewell, Murdoch, & McMurray, 2008). Making HF monitoring programs more accessible

and helpful has potentially large benefits for patients, their families and health systems. Distance monitoring programs such as TH have the ability to monitor a patient from the comforts of their own home and can be developed to perform electronic transmission of data to appropriate health professionals. This virtual network can provide a sense of comfort and connection for the patient to their care team as well as monitor outcomes (Odeh, Kayyali, Nabhani-Gebara, Philip, Robinsion, & Wallace, 2015).

Some organizations and professionals may use the terms TH and TM interchangeably. When determining which term was most appropriate for this analysis the term TH was chosen because TH programs tend to be more technologically in-depth and comprehensive than TM programming. TM can refer to the basic application of technology for patient monitoring (example: telephone based interactions) whereas TH incorporates the ability to not only monitor but can trend changes, answering text questions, provide education and relay information to monitoring centers. (U.S. Department of Health and Human Services, 2016). Comparing TH to usual care (UC) is a clinically relevant examination for society today because the technology is available to regularly monitor patients from home and intervene on transmitted data. This is pertinent because it is known that prolonged times to physician follow up leads to increased rates of hospital readmission for HF patients (Hernandez et al., 2010).

This analysis includes recently published randomized controlled trials and focuses specifically on advanced technology communication methods. This analysis is different compared to others as it focused on TH applications and did not include studies that had programs based on telephone communication unlike a recent meta-analysis by Xiang, Li, & Liu (2014) that included both TH and telephone based interventions on HF patients. Accordingly, the research question

being studied was: how do remote TH programs affect mortality, hospital readmissions and quality of life for people who are diagnosed with HF in comparison to UC?

Methods

Eligibility Criteria

For this analysis UC is defined as routine physician and/or cardiologist follow-up. TH is defined as "the use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health and health administration" (U.S. Department of Health and Human Services, 2016).

To be included for analysis the study had to be a randomized controlled trial (RCT) with participants who had a confirmed diagnosis of HF and published in an academic journal with data on at least one of the four outcomes being studied. The method for TH monitoring had to be non-invasive and have less than fifty percent of the program based on telephone or in-person aside from routine physician follow-up appointments. For the intervention to be considered non-invasive it could not have surgical implantation of a device inside the patient. Examples of invasive methods that would have been excluded from this analysis would be implanted cardioversion devices (ICD) and cardiac resynchronization therapy devices (CRT-D). Participants could be at any stage of the NYHA classification scale and there was no discrimination based on age. Included studies could not have participants with cognitive impairment (ex. dementia). Grey literature was excluded and the study had to be published in english to ensure accuracy during analysis.

The earliest publication date for study inclusion was 1995 as that was when the first major study was done that focused on home based interventions for patients with HF. This study

was completed by Rich et al. (1995) and acted as a starting point for the analysis of disease management programs for people who live with HF.

Information Search

With assistance from a librarian, a comprehensive literature search was performed using key terms of CINAHL, OVID MEDLINE, OVID EMBASE, OVID EBM reviews including CENTRAL and web of science. These databases were chosen because they are the major databases that focus on health sciences research. The selected databases were searched for publications meeting the inclusion criteria from the year 1995 to 2016. The literature search was completed by the librarian on March 8, 2016 using major headings such as: heart failure, congestive heart failure, telehealth, telemonitoring, telecare, e-health, mobile health, automated monitoring, virtual monitoring, random sample, clinical trial and random assignment. The search terms were used with a variety of combinations across databases.

The research question, inclusion and exclusion criteria and plan for the study design were discussed with the librarian prior to the search. The search strategy, search terms and search results by database are documented in Appendix A. The search results were uploaded to EndNote reference management program and subsequently screen and sorted. Search results were initially screened by title and abstract and results that were not excluded at that point were read and determined for inclusion.

Data Collection

Data from each study determined to be included in the analysis was extracted using an extraction tool that allowed a systematic approach to be taken with each study. Using the same tool and approach for each study ensured that the data extraction process was thorough and the necessary information would not be missed. An example of the extraction tool can be found in Appendix B. During the data extraction process all the studies were classified within the domains in the AHA taxonomy for disease management by Krumholz et al. (2006) however, with only eight studies included in this study sub-analyzing the disease management programs as per the taxonomy was not undertaken. General information on the intervention platform used for each study is outlined in Table 1.

Table 1. Intervention Platform Table

Study	Text message	Blue-tooth	Cellphone	Device	Description
Blum and gottlieb. (2014)				X	Philips Electronic e-care system. Monitors weight, BP/HR and 15 second rhythm strip
Dar et al. (2009)				X	Honeywell HomMed system monitoring weight, BP, SpO2. Data is transmitted via phone line to a center server
Dendale et al.(2012)		X	X		Cellphones synced with bluetooth enabled weigh scale and BP/HR devices for transmission to a server
Koehler et al. (2011)		X		X	3 lead ECG, BP and weight data transmitted to a central server
Ong et al. (2016)		X			Weigh scale, BP/HR monitoring with text questions for symptom monitoring
Schwarz et al. (2008)				X	Cardiocom EHM system weigh scale and text symptom questions (yes/no) that is transferred via a telephone line to a central server
Seto et al. (2012)	X	X	X		Blackberry cellphones connected via bluetooth to a weigh scale, BP/ECG device and yes/no text questions. Blackberry then displays a message with follow-up instructions
Soran et al. (2008)				X	DayLink monitoring system with weigh scale and yes/no symptom questions that are transmitted via phone line to a central study computer

After data extraction was completed study authors were contacted for follow up questions for missing data regarding study participant characteristics and outcome information as needed to complete the data extraction process and analyze the meta-analysis outcomes. The absence of a reply from corresponding authors regarding outcomes lead to two studies that met inclusion criteria being subsequently excluded from this analysis. There were six risk of bias domains assessed as per the Cochrane Risk of Bias tool (Cochrane Collaboration, 2016) when assessing each included study for bias. The domains are: selection bias, allocation bias, performance bias, detection bias, attrition bias, reporting bias and the presence of other bias. Each included study was assessed for bias with the PRISMA standards and Cochrane tool and are presented with the forest plot for each outcome.

Data measurement

The statistical analysis was done using Review Manager 5.3 which is the program used by the Cochrane Collaboration for meta-analyses and systematic reviews. All outcomes were assessed using a random effects model and not a fixed effects model because the intervention and control platform for each study were not identical and the diversity between studies could not be ruled out making the random effects model superior to use for data analysis. The mean difference was used for calculating the quality of life outcome because each of the studies included for analysis on quality of life used the Minnesota Living With Heart Failure Questionnaire (MLWHFQ). All outcomes used a 95% confidence interval and the results are displayed as a forest plot. Each outcome was also assessed for statistical heterogeneity. Statistical heterogeneity was measured using the I^2 percentage. The targeted I^2 percentage for each outcome was below 25% to ensure that there is consistency between the analyzed studies and to decrease the probability that the findings may be due to chance.

Results

The search results yielded 2492 results and after screening was completed there were eight RCT's that met the inclusion criteria for analysis. See figure 1, the PRISMA table for the results screening process and study selection for meta-analysis inclusion. Sample characteristics are described in table 2: the sample overall had a mean age of 70 years old with an even split between North American and European sample. The sample sizes of each study ranged from n=102 to n=1437. All of the studies were completed in North America or Europe. Study length of follow up did vary from three months to 27 months; however, the majority of the included studies had a six month length of follow up. All of the included studies only had one intervention arm and the intervention delivery was either unidisciplinary or multidisciplinary with registered nurses, nurse practitioners and/or physicians. Random effects models were used with data calculation as it is more applicable due to the variation with intervention platforms included.

An assessment for publication bias was completed (see table 3). There was evidence of between study variation regarding the methodology and study design platform. This was expected because of the diverse ways that technology can be applied to healthcare (ex. cell-phone technology vs standardized BP/weigh scale monitoring devices). The performance bias is high in every study but due to the nature of the intervention this was not avoidable by the researchers because after randomization the participants would know if they were in TH or UC group. Some studies did not have the investigators blinded as they were actively involved with monitoring the intervention participants and following up with alerts received resulting in a high level of detection bias (Koehler et al., 201; Ong et al., 2016; Schwarz et al., 2008) Biases are reported as unclear when the study did not have enough information present in the publication to clearly determine a high or low bias.

Figure 1. PRISMA Table for Study Selection

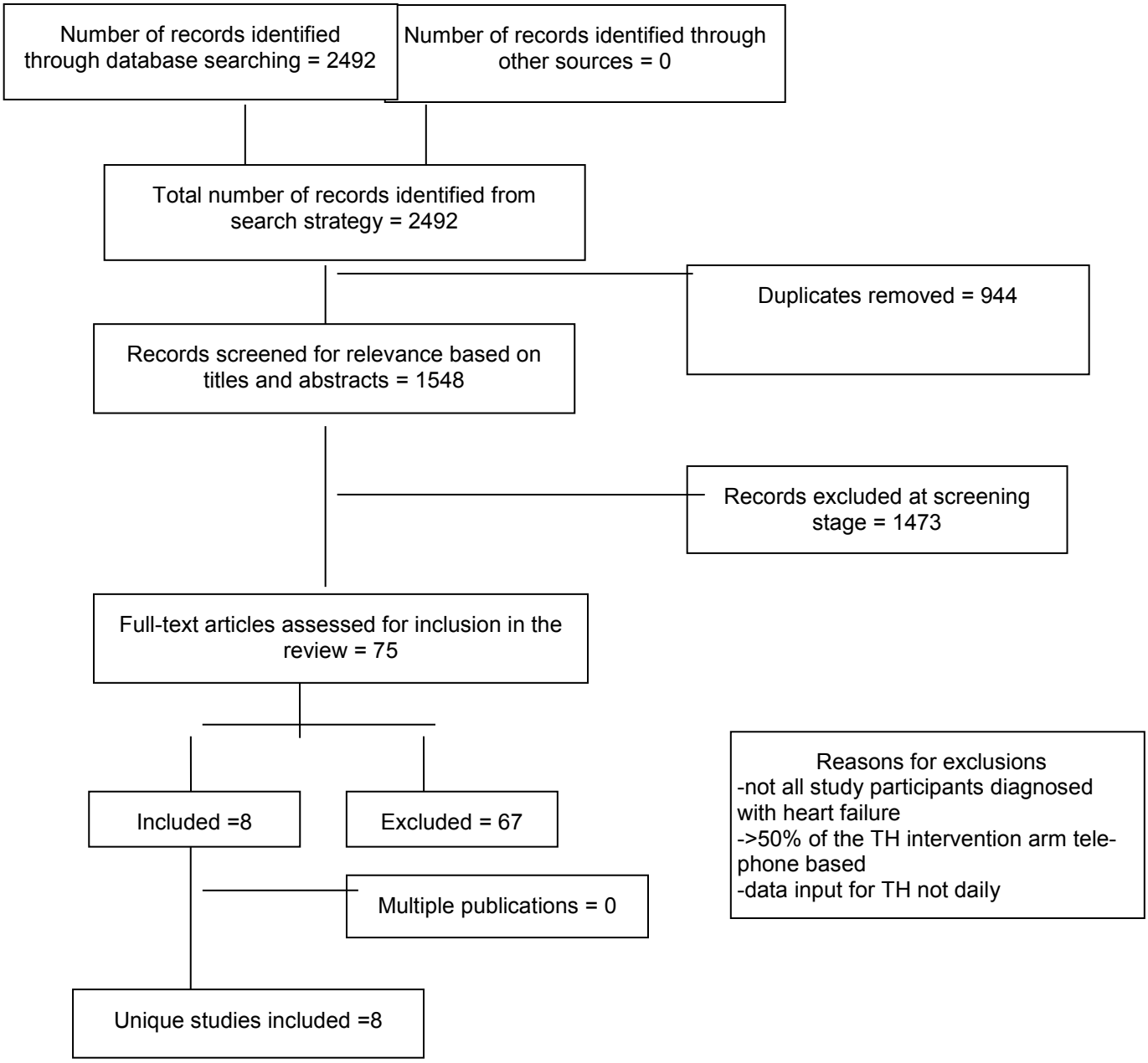


Table 2: Study Characteristics Table

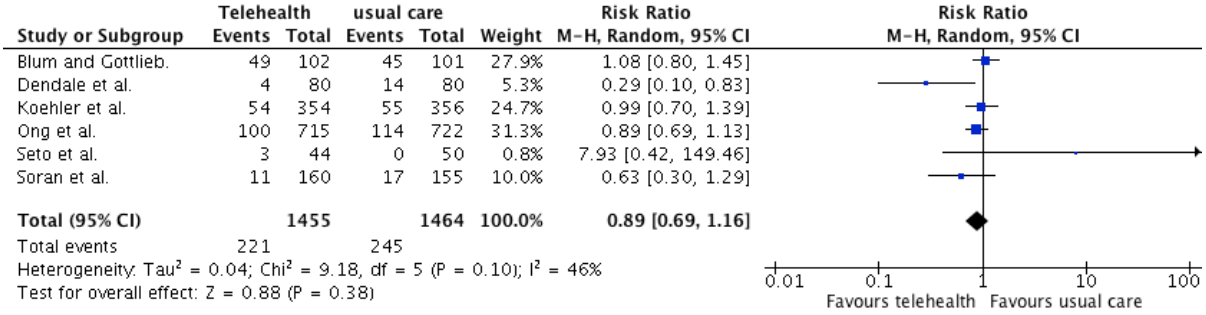
Author (year)	N	Mean(SD) age	Country	Length of follow up
Schwarz et al. (2008)	102	UC=77.1(7.3) TH=79.1(6.9)	United States of America	3 months
Soran et al. (2008)	315	UC=76.0(6.8) TH=76.9(7.1)	United States of America	6 months
Dar et al. (2009)	182	UC=72(10.4) TH=70(12.8)	United Kingdom	6 months
Koehler et al. (2011)	710	UC=66.9(10.5) TH=66.9(10.8)	Germany	24 months
Dendale et al. (2012)	160	UC=75.6(9.8) TH=75.9(9.6)	Belgium	6 months
Seto et al. (2012)	100	UC=52.3(14.34) TH=55.1(13.7)	Canada	6 months
Blum and Gottlieb. (2014)	204	UC=72(10) TH=73(8)	United States of America	Median of 823 days (27 months)
Ong et al. (2016)	1437	UC=73(16) TH=74(14)	United States of America	6 months

Table 3: Table for Publication Bias

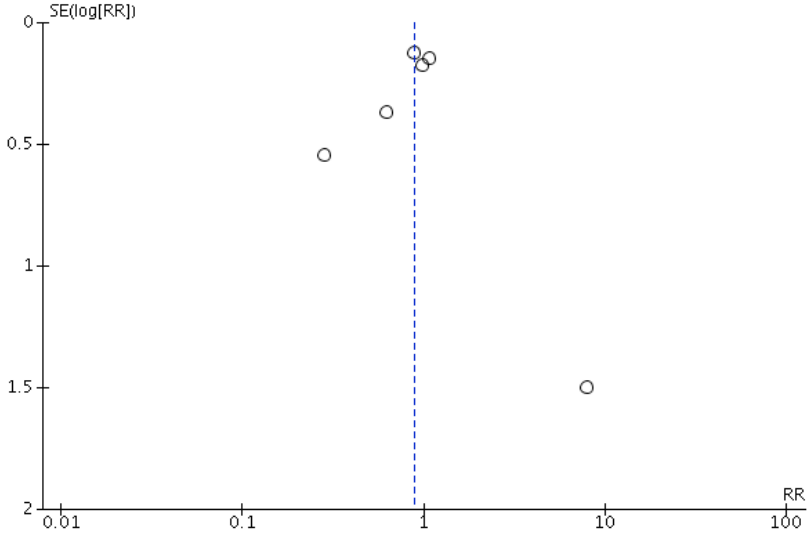
Study	Selection Bias	Allocation Bias	Perfor-mance Bias	Detection Bias	Attrition Bias	Reporting Bias
Blum and Gottlieb.	high	high	high	low	low	low
Dar et al.	high	high	high	low	high	high
Dendale et al.	unclear	low	high	low	low	low
Koehler et al.	low	high	high	high	low	low
Ong et al.	low	low	high	high	low	low
Schwarz et al.	high	unclear	high	high	low	low
Seto et al.	low	low	high	unclear	low	low
Soran et al.	unclear	unclear	high	low	low	low

All-Cause Mortality

Six studies contained extractable data on all-cause mortality (2008 to 2016, n: 2926). Overall, a non-significant trend towards reducing all-cause mortality was evident but there was no evidence of a statistically significant reduction in mortality (RR0.89, 95% CI 0.69-1.16, p=0.38). The I^2 is 46% giving this outcome a moderate amount of statistical heterogeneity. This shows that there is some variation across the studies analyzed but that the studies are still similar enough to be an appropriate comparison. The study by Seto et al. is an outlier in this outcome because they reported no deaths in the UC group which caused a large CI (95% CI 0.42-149.46).



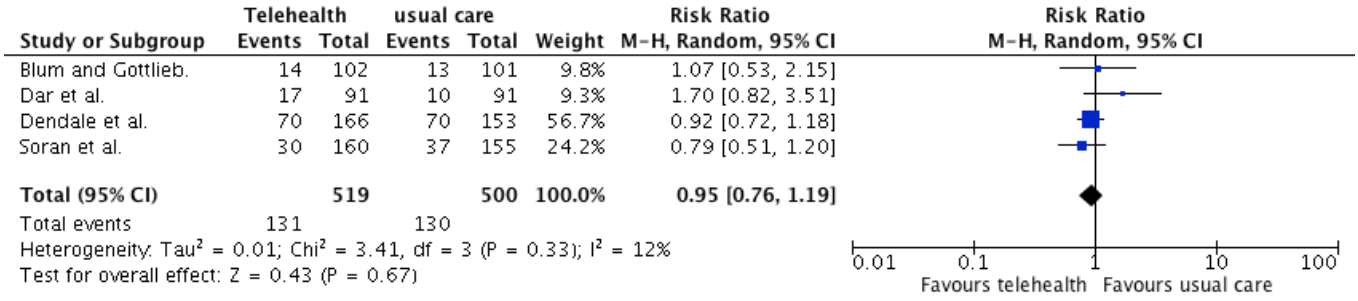
4.1 Forest Plot: All-cause mortality



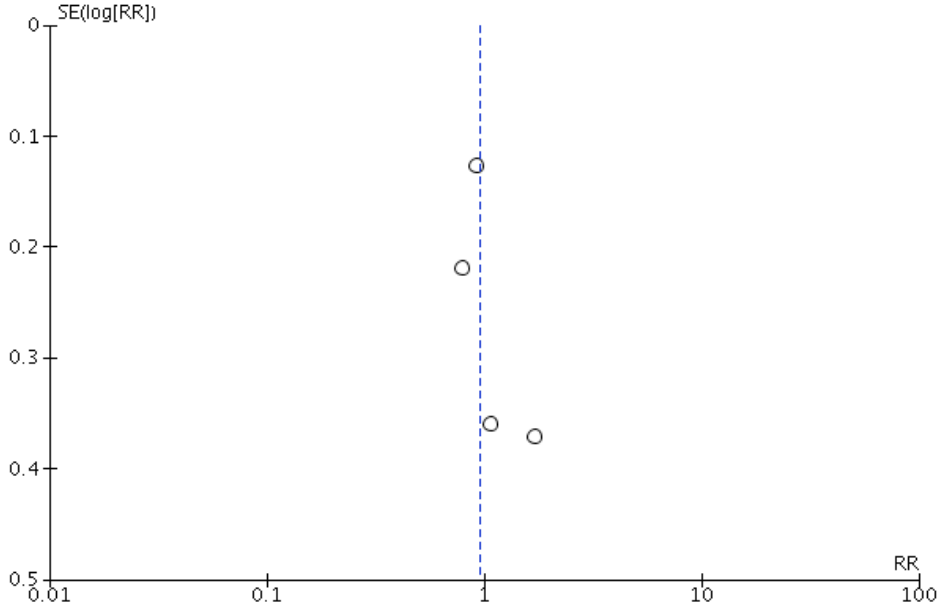
5.1 Funnel Plot: All-Cause Mortality

Heart Failure Related Hospitalizations

Four studies contained extractable data on heart failure related hospitalizations (2008 to 2014, n=861).There was a non-significant trend towards reducing heart failure related hospitalizations was evident but there was no evidence of a statistically significant reduction (RR0.95, 95% CI 0.76-1.20, p=0.67). Heterogeneity testing shows a I^2 =12% with the studies analyzed for heart failure related hospitalizations. With such little heterogeneity the outcomes analyzed are comparable and had a very small amount of variation between studies.



4.2 Forest plot: Heart Failure Related Rehospitalization



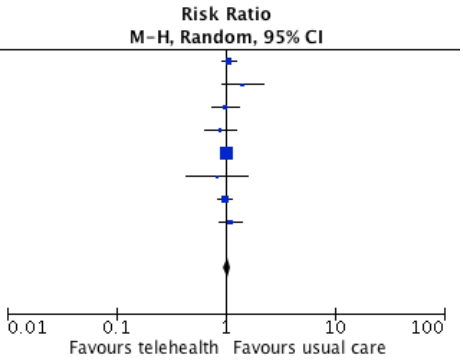
5.2 Funnel Plot: Heart Failure Related Rehospitalization

All-Cause Rehospitalization

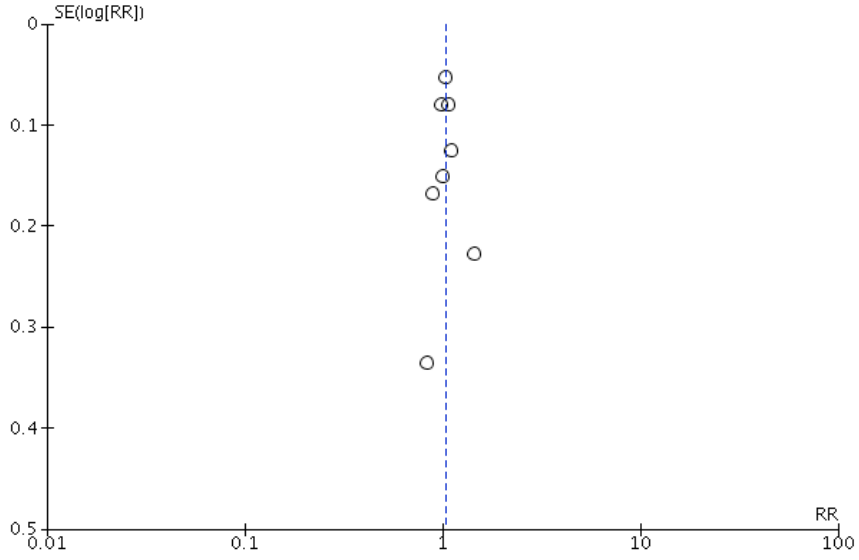
All eight studies contained extractable data on all-cause rehospitalization (2008-2016, n=3210). Effects were very similar between groups and there was no evidence of a statistically significant trend towards reducing all cause rehospitalization (RR 1.03, 95% CI 0.96-1.10, p=0.76). The I^2 for this outcome is 0% showing that when all the studies included for this analysis are comparable and statistical heterogeneity does not exist.

Study or Subgroup	Telehealth Events	Total	usual care Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Blum and Gottlieb.	80	102	74	101	18.7%	1.07 [0.92, 1.25]
Dar et al.	33	91	23	91	2.3%	1.43 [0.92, 2.24]
Dendale et al.	42	80	42	80	5.2%	1.00 [0.74, 1.34]
Koehler et al.	56	354	63	356	4.2%	0.89 [0.64, 1.24]
Ong et al.	363	715	355	722	42.4%	1.03 [0.93, 1.15]
Schwarz et al.	12	44	13	40	1.0%	0.84 [0.43, 1.62]
Seto et al.	38	44	44	50	18.7%	0.98 [0.84, 1.15]
Soran et al.	75	160	66	155	7.5%	1.10 [0.86, 1.41]
Total (95% CI)		**1590**		**1595**	**100.0%**	**1.03 [0.96, 1.10]**
Total events	699		680			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 4.14$, df = 7 (P = 0.76); $I^2 = 0\%$
Test for overall effect: Z = 0.92 (P = 0.36)



4.3 Forest plot: All-cause rehospitalization



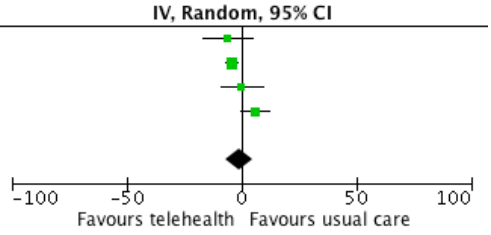
5.3 Funnel plot: All-cause rehospitalization

Quality of Life

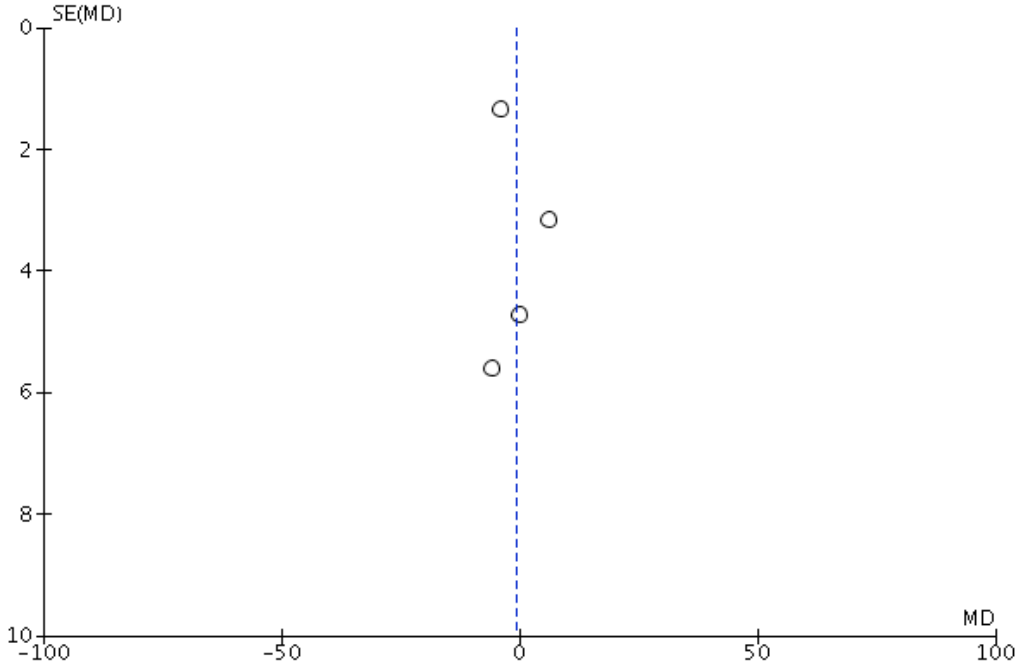
Four studies contained extractable data on quality of life (2008 to 2014, n=406). The mean difference (MD) was used for this analysis as all of the studies used the MLWHFQ to analyze quality of life. Effects on quality of life were similar across intervention and usual care groups and there was no evidence of a statistically significant improvement in quality of life (MD -0.83, 95% CI -6.59 to 4.94, p=0.78). I^2 =68% giving this outcome a moderate amount of heterogeneity but the percentage is still small enough that the outcomes are comparable.

	Telehealth			usual care				Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Seto et al.	41.4	26.7	38	47.3	23.4	44	16.3%	-5.90 [-16.85, 5.05]	
Ong et al.	28.5	24	715	32.63	27	722	36.8%	-4.13 [-6.77, -1.49]	
Schwarz et al.	27.4	21.7	44	27.3	21.6	40	19.6%	0.10 [-9.17, 9.37]	
Blum and Gottlieb.	24	24	102	18	21	101	27.3%	6.00 [-0.20, 12.20]	
Total (95% CI)			**899**			**907**	**100.0%**	**-0.83 [-6.59, 4.94]**	

Heterogeneity: Tau² = 21.71; Chi² = 9.35, df = 3 (P = 0.02); I² = 68%
Test for overall effect: Z = 0.28 (P = 0.78)



4.4 Forest Plot: Quality of life



5.4 Funnel Plot: Quality of Life

Discussion

This analysis showed that TH interventions for HF patients had no clear benefits over usual care. This should not imply that TH concepts do not have a place in HF management, the American Heart Association guidelines by Yancy et al. (2013) have thorough recommendations for the management of HF but do not include the recommendation for the use or avoidance of TH which still makes this investigation relevant. The trials involved in this analysis were based out of large tertiary facilities that are likely to have effective UC and most of the included studies did not specify if there was a difference between urban and rural patients. Comparing outcomes on rural vs urban dwelling participants was not completed on this analysis because not enough of the included studies reported this information on their participants.

This analysis focused TH to the use of advancing technology measures such as Ipads/tablets, mobile phones (text messaging), internet and industry designed devices. This was done to reduce the clinical heterogeneity between studies and focus the number of remote monitoring interventions for this analysis. The definition of UC was considered usual cardiologist/physician follow up without using telehealth methods. There is some variance between the studies on what is considered to be UC, this is relatable to patient monitoring practices today because it is recommended by the American Heart Association that in addition to physician monitoring HF patients have follow up with an integrated multidisciplinary team(Grady et al. 2000). Studies that mentioned cardiac rehabilitation programs as a comparison were not included because cardiac rehabilitation is a specialized monitoring program that differs from UC and TH concepts and would have made the comparisons less defined and the results less meaningful to the body of literature on this topic.

One TH limitation may be that the technology used with some of the interventions was not as portable as patients needed it to be to adequately incorporate it into their daily living (ex, devices requiring wired connections). A systematic review by Clark et al. (2016) found that technology based HF management interventions had a positive effect on patients self-care practices if the program had routine access to technical support, was easily portable and user friendly. Living with HF will impact the daily living routines of patients and it is important for practitioners to recognize the actual and potential challenges for patients. The practitioner needs to work with the patient to improve their self-care strategies and coping mechanisms (Harkness, Spaling, Currie, Strachan & Clark, 2015). Additionally, incorporating technology into daily living may be difficult for some HF patients, and it will be imperative that TH practitioners work with the patient to reduce the barriers and stressors when implementing a program for to improve patient success (Hall, McArthur, & Colton, 2014).

Included studies ranged in publication dates from 2008-2016 and even though it is only eight years, technology has advanced significantly in that time. To put that into perspective, the first iPhone was introduced in 2007 and by 2016 there have been 13 different models released. The first model had a maximum capacity of eight GB whereas the newest models have the ability to hold up to one hundred twenty-eight GB and perform multiple tasks, transmit data, connect wirelessly to other devices and real-time video call (Apple Inc, 2016). This consideration of technology and its advances is imperative when interpreting the results of this meta-analysis. The results of this study are non-conclusive but it does not mean that the technology currently being studied or developed will have a significant impact on future HF patients.

The statistical heterogeneity (I^2) for the outcomes ranged from zero to sixty-eight percent, quality of life has the largest I^2 percentage which does show that there is an element of heteroge-

neity present. This was not surprising because there is some variability with the TH intervention methods used and the methodologies influencing each study; however, the results are still generalizable to the population because the inclusion criteria were specific regarding appropriate TH methods that could be included. The presence of methodological heterogeneity is suspected because of the differences in the TH programs included, for example, portable Bluetooth enabled devices versus stationary devices requiring a direct connection. A clinically relevant heterogeneous factor to consider that could impact patient outcomes is the delay from when a patient TH data is transmitted to when the practitioner monitoring the patient would be altered to an issue (Altman & Ashley, 2015).

The results of this study do not demonstrate a superior method which may lead some to view this analysis as not being beneficial to the body of knowledge on HF care. The opposite is true because analyses that do not find strong benefits for interventions demonstrate that there is still required learning on the topic and room for further research (Clark & Thompson, 2010). Further research on this topic focusing on directly comparing different TH methods may be beneficial to determine if there is a superior TH method for HF patients that can then be compared to UC.

Contribution to Nursing

Nurses play a pivotal role in the care of HF patients, their knowledge and expertise is critical with the ongoing monitoring of patients, detection of changes and prevention of complications. In research, nursing is a profession that is routinely incorporated into assisting with study development, implementation, monitoring of participants and dissemination of findings (Gibbs & Lowton, 2012). In this analysis, seven of the eight included studies reported using registered nurses (RN) and/or nurse practitioners (NP). With nursing having an active role with UC

and TH technology this study is important to the profession because nurses are involved with HF patients on a broad spectrum.

Even though the results of this study do not show that there is a statistically significant difference between current UC practices and the use of TH it is still useful to nursing practice, and that nurses who are working with HF patients with either follow up strategy are having an equal impact on patients. The continued inconclusiveness of this issue is also a point for further research on this topic that nurses should be involved with. Nurses who practice in the UC or TH setting can work to better define their monitoring strategy with patient needs, and make the programs work better which may one day lead to a conclusive strategy to monitor HF patients and improve outcomes.

Society as a whole is becoming increasingly dependent on technology and personal devices making them a central aspect of completing everyday tasks at home and the workplace, this is no exception for nursing and healthcare. All aspects of nursing care is rapidly changing including communication, documentation, monitoring, medication dispensing, procedures and teaching. Theoretically, the concept of TH can encompass most aspects of nursing care and increase the convenience and sense of connection for HF patients at the same time (Atkin & Barrett, 2012). As remote monitoring programs become more accessible for people living with HF nurses will need to ensure that they are keeping up with technology and understand how it can be used to best serve those in need. Nursing is becoming the profession that performs the routine monitoring and follows HF patients who use TH. Nurses can be a central partner and advocate for how TH programs are run there should be formal education opportunities for nurses who regularly use TH in their practice (Atkin & Barrett, 2012). With the potential to have a significant impact on how patient care will be provided using TH in the future, nurses need to take this op-

portunity to work closely with this population and have their voice heard to make the benefits of TH programs for HF patients less ambiguous, and drive changes that leads to positive outcomes and health behaviours

Conclusion

No statistically significant difference was found for all-cause mortality, heart failure related hospitalization, all-cause rehospitalization and quality of life for HF patients who used TH vs HF patients who were treated with UC. Despite using a clear definition of TH and the most up to date information available, the findings on this still remain inconclusive. The availability of TH continues to increase and become more readily used by HF patients as technology is more adaptable to secondary disease management programs and healthcare. Future research should focus on further defining TH and using a unanimously agreed upon term. This could aide with ensuring that the interventions are comparable when completing future research and assessing the effectiveness for TH to impact HF patients and determine which intervention method is superior to work toward improving patient outcomes.

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Appendix A: Search Strategy

Telehealth CHF RCTs Search
by Dagmara Chojecki, MLIS

OVERVIEW

Databases:
Ovid MEDLINE
OVID EMBASE
OVID EBM Reviews (Cochrane Library) including:
Cochrane Central Register of Controlled Trials (CENTRAL)
Web of Science
CINAHL

Search syntax has been customized for each database.

Date of Search: March 8, 2016
Study Types: Randomized controlled trials (RCTS)
Limits: None
Note:
†† "*", "# ", and "?" are truncation characters that retrieve all possible suffix variations of the root word e.g. surg* retrieves surgery, surgical, surgeon, etc.

Database	Date Searched	Search Strategy
Ovid Medline In-Process & Other Non-Indexed Citations and **Ovid MEDLINE**(R) 1946 to Present	March 8, 2016 Results 348	1 telemedicine/ or remote consultation/ 16444 2 (remote adj2 (monitoring or management or consult*)).mp. 5489 3 (virtual adj2 (management or coordination)).mp. 41 4 telemonitoring.mp. 858 5 (telehealth or telemedic* or telemanagement).mp. 16766 6 (automated adj2 monitoring).mp. 475 7 telephonic disease management.mp. 7 8 (mhealth or m health or mobile health).mp. 4743 9 (ehealth or e health or electronic health).mp. 16007 10 (telecare or telecardiology or teleconsult* or teletherapy).mp. 7158 11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 45440 12 exp Heart Failure/95932 13 (heart failure or CHF).mp. 155184 14 12 or 13 155984 15 11 and 14 923 16 randomized controlled trial.pt. 409672 17 clinical trial.pt. 497909 18 randomi?ed.ti,ab. 433666 19 placebo.ti,ab. 171966 20 dt.fs. 1829244 21 randomly.ti,ab. 244778 22 trial.ti,ab. 414066 23 groups.ti,ab. 1549431 24 or/16-23 3835439 25 animals/ 5793945 26 humans/ 15735890 27 25 not (25 and 26) 4170620 28 24 not 27 3315831 29 15 and 28 348

OVID EM-BASE	March 8, 2016 796 results	1 *telehealth/ or *telemedicine/ or *telecardiology/ or *teleconsultation/ or *telemonitoring/ or *teletherapy/ 12466 2 (remote adj2 (monitoring or management or consult*)).mp. 2895 3 (virtual adj2 (management or coordination)).mp. 52 4 telemonitoring.mp. 2019 5 (telehealth or telemedic* or telemanagement).mp. 19169 6 (automated adj2 monitoring).mp. 504 7 telephonic disease management.mp. 15 8 (mhealth or m health or mobile health).mp. 1638 9 (ehealth or e health or electronic health).mp. 11770 10 (telecare or telecardiology or teleconsult* or teletherapy).mp. 9173 11 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 40436 12 exp heart failure/ 296803 13 (heart failure or CHF).mp. 237720 14 12 or 13 323376 15 11 and 14 1927 16 exp clinical trial/ 916954 17 randomi?ed.ti,ab. 539668 18 placebo.ti,ab. 182338 19 dt.fs. 2449250 20 randomly.ti,ab. 272884 21 trial.ti,ab. 483730 22 groups.ti,ab. 1656574 23 or/16-22 4526274 24 animal/ 767240 25 human/ 11636441 26 24 not (24 and 25) 529139 27 23 not 26 4425300 28 15 and 27 796

EBM Reviews: **CENTRAL**	March 8, 2016 258 results	1 (remote adj2 (monitoring or management or consult*)).ti,ab,sh,kw. 2 (virtual adj2 (management or coordination)).ti,ab,sh,kw. 3 telemonitoring.ti,ab,sh,kw. 4 (telehealth or telemedic* or telemanagement).ti,ab,sh,kw. 5 (automated adj2 monitoring).ti,ab,sh,kw. 6 telephonic disease management.ti,ab,sh,kw. 7 (mhealth or m health or mobile health).ti,ab,sh,kw. 8 (ehealth or e health or electronic health).ti,ab,sh,kw. 9 (telecare or telecardiology or teleconsult* or teletherapy).ti,ab,sh,kw. 10 or/1-9 11 (heart failure or CHF).ti,ab,sh,kw. 12 10 and 11
Web of Science	March 8, 2016 604 results	# 14 #13 AND #12 Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 13 TS= clinical trial* OR TS=research design OR TS=comparative stud* OR TS=evaluation stud* OR TS=controlled trial* OR TS=follow-up stud* OR TS=prospective stud* OR TS=random* OR TS=placebo* OR TS=(single blind*) OR TS=(double blind*) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 12 #11 AND #10 Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 11 TOPIC: (heart failure or CHF) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 10 #9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1 Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 9 TOPIC: ((telecare or telecardiology or teleconsult* or teletherapy)) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 8 TS=((ehealth or e-health or "electronic health")) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 7 TS=((mhealth or m-health or "mobile health")) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 6 TOPIC: (telephonic disease management) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 5 TOPIC: ((automated NEAR/2 monitoring)) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 4 TOPIC: ((telehealth or telemedic* or telemanagement)) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 3 TOPIC: (telemonitoring) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 2 TOPIC: ((virtual NEAR/2 (management or coordination))) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016 # 1 TOPIC: ((remote NEAR/2 (monitoring or management or consult*))) Indexes=SCI-EXPANDED, SSCI Timespan=2000-2016

CINAHL	March 8, 2016 485 results	S17 S15 AND S16 S16 ((MH "Random Assignment") or (MH "Random Sample+") or (MH "Crossover Design") or (MH "Clinical Trials+") or (MH "Comparative Studies") or (MH "Control (Research)+") or (MH "Control Group") or (MH "Factorial Design") or (MH "Quasi-Experimental Studies+") or (MH "Placebos") or (MH "Meta Analysis") or (MH "Sample Size") or (MH "Research, Nursing") or (MH "Research Question") or (MH "Research Methodology+") or (MH "Evaluation Research+") or (MH "Concurrent Prospective Studies") or (MH "Prospective Studies") or (MH "Nursing Practice, Research-Based") or (MH "Solomon Four-Group Design") or (MH "One-Shot Case Study") or (MH "Pretest-Posttest Design+") or (MH "Static Group Comparison") or (MH "Study Design") or (MH "Clinical Research+")) or (clinical nursing research or random* or cross?over or placebo* or control* or factorial or sham* or meta?analy* or systematic review* or blind* or mask* or trial*) S15 S11 AND S14 S14 S12 OR S13 S13 heart failure or CHF S12 (MH "Heart Failure+") S11 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 S10 telecare or telecardiology or teleconsult* or teletherapy or telenursing S9 ehealth or e-health or electronic health S8 mhealth or m-health or mobile health S7 telephonic disease management S6 automated N2 monitoring S5 (telehealth or telemedic* or telemanagement) S4 telemonitoring S3 (virtual N2 (management or coordination)) S2 (remote N2 (monitoring or management or consult*)) S1 (MH "Telehealth") OR (MH "Telemedicine") OR (MH "Remote Consultation") OR (MH "Telenursing")

Appendix B: Extraction Sheet Example

Impact of Remote Telehealth on Patients with Heart Failure: a meta-analysis

Paper title:
Study Author(s):
Year:

Journal citation:

Country(s) of setting:

Primary Reviewer (initials):

Secondary Reviewer (initials): _____

TOTAL STUDY POPULATION

	N	Mean Age (SD)	%
Total			**100**
Males			
Females			

NOTES

STUDY DESIGN

CONTROL GROUP(S)

RCT (by patient)
Clustered RCT

Categorization of comparison group

Control(1)

Usual care (not described)
Basic usual care[1]

Cardiac Outpatient Clinic based

[1]Basic usual care: General Medical or nursing / health care *with no specific support* for disease management
Study quality appraisal

Cochrane Biases (Comments)	**Low**	**Unclear**	**High**
	(Check mark only)		
Selection bias:			
Performance bias:			

Detection bias:			
Attrition bias			
Reporting bias			
Other biases			

PROGRAM COMPONENTS

RESULTS REPORTED

Primary outcomes

1. All-cause mortality

	Intervention	**Control (1)**
Total	/	/
Males	/	/
Females	/	/
Completeness of FU		

2. Heart failure deaths

	Intervention	**Control (1)**
Total	/	/
Males	/	/
Females	/	/
Completeness of FU		

3. HF-related Morbidity (hospitalizations due to heart failure)*

	Intervention	**Control (1)**
Total	/	/
Males	/	/
Females	/	/
Completeness of FU		

***: "Number of pts who have a recurrent event"**

3. Morbidity (decompensation in heart failure)

	Intervention	**Control (1)**
Total		
Males		
Females		
Completeness of FU		

4. Quality of Life
(NB: INCLUDE ALL STANDARD DEVIATIONS IN THE FOLLOWING)

	Intervention v Control (1) (SD)

Total	
Males	
Females	
Completeness of FU	

(Include actual data with trend in bracket: ++, +, 0, -)

Name of instrument(s)_____

Outcomes classified with the AHA Taxonomy for Disease Management

20. Patient Population (age)

	Intervention vs. control (1) (SD)	**Intervention vs. control (2) (SD)**
Total		
50 years of age or younger		
50-60 years of age		
60-70 years of age		
70-80 years of age		

80 years of age or older		
Completeness of FU		

21. Patient population (geographical location: continent)

	Intervention vs. control (2) (SD)	**Intervention vs. control (2) (SD)**
Total		
North America		
South America		
Europe		
Asia		
Australia		

Africa		
Completeness of FU		

22. Patient population (urban or rural)

	Intervention vs. control (1) (SD)	**Intervention vs. control 2 (SD)**
total		
urban		
rural		
Completeness of FU		

23. Patient population (sex)

	Intervention vs. control (1) (SD)	**Intervention vs. control (2) (SD)**
total		
Male		
Female		

Completeness of FU		

24. Intervention Platform

	Intervention vs control (1) (SD)	**Intervention vs control (2) (SD)**
total		
Text/smartphone		
E-mail		
Web based		
Ipad/Tablet		
********Telephone*******		
Completeness of FU		

25. Recipient (NYHA class)

	Intervention vs. control (1) (SD)	**Intervention vs. control (2) (SD)**

total		
NYHA class 1		
NYHA class 2		
NYHA class 3		
NHYA class 4		
Completeness of FU		

26. Program content

	Intervention vs. control (1) (SD)	**Intervention vs. control (2) (SD)**
total		
50% or greater of intervention program is by telehealth		
50% or less of intervention program is by telehealth		
Completeness of FU		

27. Delivery personnel

	Intervention vs. control (1) (SD)	**Intervention vs. control (2) (SD)**
total		
Unidisciplinary		
Multidisciplinary		
Completeness of FU		

28. Complexity: Length of program

	Intervention vs. control (1) (SD)	**Intervention vs. control (2) (SD)**
total		
less than 6 months		
6 months to 1 year		
1-2 years		
greater than 2 years		
Completeness of FU		

29. Intensity: data input into telehealth program

	Intervention vs. control (1) (SD)	**Intervention vs. control (2) (SD)**
total		
once daily		
twice daily		
three times daily or greater		
Completeness of FU		

30. Publication date of study

	Publication date
total	
1995-2000	
2001-2005	
2006-2010	
2011-2015	

Completion of Follow Up

Mean percentage of patients from baseline for whom follow up data were available

Group	Time point(s)	Completion (%)	Males	Females
Intervention total				
Comparison Group1				
Comparison Group 2				

AUTHOR EMAIL SURVEY

Follow up author survey on outcomes if needed

Authors contacted	Email	Date sent	Reply (Y/N)
1.			
2.			
3.			

Notes on questions / variables for author follow up
1.
2.
3.
4.
5.
6.