Spring 4-19-2020

Home Telemonitoring in Heart Failure

William Huff

University of Texas at Tyler, whuff@patriots.uttyler.edu

Home Telemonitoring in Heart Failure Benchmark Project

A Paper Submitted in Partial Fulfillment of the Requirements

For NURS 5382

In the School of Nursing

The University of Texas at Tyler

by

William Huff

April 19, 2020

Executive Summary

Heart failure (HF) exacerbation is a major source of hospitalization, mortality, and healthcare cost to home health agencies. Unmonitored accumulative fluid retention between skilled nurse visits, base knowledge deficits in HF pathophysiology and dietary restrictions, and lack of basic monitoring equipment such weighing scales are primary contributors to HF related hospitalizations in the home health setting. It has been discovered that early recognition of decompensating HF can reduce or eliminate HF related hospitalization, mortality, and healthcare costs associated with the management of exacerbation. When a patient is sent to the emergency room (ER) for fluid overload secondary to HF, massive costs are generated including ER transportation, ER consultation fees, hospital stay fee if admitted, and increased home health visit fees for adding additional skilled nurse visits for follow up assessments. Having a method of filling in the monitoring gaps of this patient population can reduce negative outcomes associated with managing HF in home health.

The current method of monitoring weekly or bi-weekly by a skilled nurse in these complex HF patients is not best practice. For patients to receive improved and effective HF monitoring on non-skilled nurse days, additional monitoring options should be implemented. Technological advancement in modern healthcare allows the integration of technology to aide in reducing the negative impact HF exacerbation has on home health agencies. Telemonitoring (TM) heart failure in the home health setting is an evidence-based implementation option to reduce patient mortality, decrease healthcare costs, and assist healthcare providers in accessing current and relevant data for point-of-care decision making. TM devices should be installed in the homes of patients who meet the HF exacerbation risk criteria to reduce hospitalization, mortality, and healthcare costs.

Rationale

Patients in home health often receive inadequate HF monitoring with severe negative consequences. The primary internal reasons for lack of adequate HF monitoring include staffing inadequacies, insurance providers refusing to pay for additional skilled nurse visits, patients having moderate to severe knowledge deficits in HF disease process management, and lack of hemodynamic monitoring equipment. Unfortunately, HF related hospitalizations continue to occur frequently incurring severe negative consequences affecting all health care disciplines involved.

The exponential financial burden of multiple heart failure related hospitalizations has warranted investigation in alternative evidence-based methods of HF monitoring as it is the role of the clinician to identify organizational change needed and to find the best available evidence to support this change (Melnyk & Fineout-Overholt, 2015). Creating an avenue for daily home monitoring of HF by skilled clinicians allows for rapid assessment and intervention that may otherwise not have taken place. This provides the opportunity to contact primary care providers for pharmacological intervention to reduce HF related hospitalization and mortality.

The goal of this benchmark project is to bring light to the fact that the current system of monitoring HF in this patient demographic is not effective and should be changed. The primary rationale of searching for HF monitoring solutions arose from multiple internal documented cases of HF exacerbation in patients who met the criteria for TM devices but did not have them available. As more insurance companies switch to pay for performance reimbursement strategies, reimbursement rates for HF patients with preventable hospitalization will likely decline, further inflating the cost of caring for these patients. The goal of this project is using the implementation of TM devices in qualifying patient homes to reduce HF related hospitalization, mortality, healthcare costs, and reduce negative outcomes.

Literature Synthesis

The literature search was conducted using the Cumulative Index to Nursing and Allied Health Literature Database, Cochrane Library, and PubMed. The criteria included the keywords "telemonitoring" and "heart failure". Only articles including patients over the age of 60 with a diagnosis of heart failure and active cardiac telemonitoring with the highest available levels of evidence were utilized. Gensini, Alderighi, Rasoini, Mazzanti, and Casolo (2017) stated, "It is crucial to identify the most relevant biological parameters to monitor, which heart failure sub-populations may gain real benefits from telehealth interventions and in which specific healthcare subsets these interventions should be implemented in order to maximize value" (p. 116). To support the feasibility and applicability of the implementation of TM into home health practice, multiple randomized control trials (RCT), meta-analyses (MA) were thoroughly reviewed.

The primary beneficial factors sought for the benchmark project were decreased HF hospitalization and mortality rates. Several studies clearly showed the benefit of TM implementation. An overview of 19 systematic reviews found that TM was effective in reducing mortality and heart failure rehospitalization (Bashi et al., 2017). This study specifically included rehospitalization as part of the review process. Boyne et al. (2017) found that tailored TM improved patient education and self-efficacy. These are factors that are crucial for long-term management of HF. A RCT by Delaney et al. (2013) found that TM significantly reduced hospitalization and increased HF related knowledge compared to the group with no TM. An additional RCT found that using TM to track and improve adherence to HF medications including diuretics showed to be beneficial to most HF patients (Gallagher et al., 2017). A unique RCT that studied implant-based TM directly showed a significant improvement in clinical outcomes and a strong recommendation for TM practice implementation (Hindricks et al., 2014). A MA by Kitsiou et al. (2015) found home TM reduced the relative risk of all-cause mortality and HF related hospitalization. This finding was significant in the fact that it related specifically to the benchmark project goals.

A review of over 30 RCT with more than 10,000 patients found that TM reduced the odds of mortality and hospitalization in HF patients compared to not using TM (Kotb et al., 2015). A study design that used TM tablet computers in the home found that HF knowledge and health related quality of life increased significantly while decreasing hospitalization (Melin et al., 2018). It was important during the article search that evidence was obtained that supports long term application of TM. A MA by Tse et al. (2018) found that TM reduced HF related hospitalization in both the short and long-term. A MA of 37 RCT with 9582 patients concluded that TM intervention reduced mortality risk associated with HF and found that increasing the frequency of TM data transmission was associated with increased effectiveness (Yun et al., 2018). An additional supporting MA with 29 RCT and 10,981 patients concluded that TM reduced HF mortality, hospitalizations, and additionally reduced the length of hospital stay (Zhu et al., 2019). The supporting evidence that provided the benefit of TM implementation was substantial.

Stakeholders

The internal stakeholders of the project who are directly affected include the executive director (ED), director of patient care services (DPCS), and senior vice president (SVP) of the region. The DPCS is the first to know about the implementation of any new projects. Once cleared and approved by the DPCS, the ED is notified for a review of the project goals. The ultimate authority for implementation in turn is greenlighted by the regional SVP. If the benchmark project is implemented nationally, additional corporate stakeholders may be indicated for consultation and approval.

External stakeholders and those indirectly affected include the Cardio-com TM team as suppliers and the patients as customers. Additional stakeholders include the providers responsible for ordering home health and the payors responsible for paying for covered services. The stakeholder's primary desires include reliable and functional telemonitoring devices to provide quality data that is easily interpretable. The rationale for this stakeholder preference is decreased failure rate from the telemonitoring device to provide the most accurate data to prevent heart failure hospitalization, decreasing healthcare costs.

Implementation

The benchmark project implementation plan is straightforward. An overview of the implementation plan includes obtaining the TM devices, setting up the software, selecting the patient population and staff, setting up the TM devices in the patient homes, and monitoring and acting on the provided data to identify and intervene when heart failure exacerbation is suspected. The first step in implementing this project includes contacting the Cardio-com TM device distributor and renting the number of TM devices that fits the specified patient population and specific agency needs. Once the TM devices are rented, the manufacturer will ship and deliver the TM devices to the agency of choice so they will be available for distribution to the qualifying homes. The second step of implementation includes registering the devices after they are delivered and downloading the monitoring software to existing company laptops. The third step of implementation includes determining the patient population that will receive the TM devices. Ideally this will include patients 60 years and older with heart failure. The fourth step of implementation includes selecting staff members who are responsible for daily monitoring of the data and notifying the ordering provider for notification parameter orders and any standing diuretic or other intervention orders. The fifth step of implementation includes installing the TM devices in the patient homes and instructing the patients on how to transmit data and to perform data transmission once daily for review. The sixth and final step of the implementation project includes monitoring the transmitted data for timely intervention. The staff will be alerted to patients reporting signs or symptoms of heart failure including increased shortness of breath, decreased urination, orthopnea, activity intolerance, edema, and weight increase as well as medication compliance.

Timetable

The timeline for the benchmark project implementation is designed so the implementation phase can be completed in ten days or less for maximal benefit to the patient through early intervention. The first step of contacting the Cardio-com TM device distributor, renting the number of TM devices that fits the specified patient population and specific agency needs, and the delivery of the devices from the manufacturer should be completed on days one through three. The second step of registering the devices after they are delivered and downloading the monitoring software to existing company laptops should be completed by days four through five. The third step of determining the patient population that will receive the TM devices should occur between days six through seven. The fourth step of selecting staff members who are responsible for daily monitoring of the data and notifying the ordering provider for notification parameter orders and any standing diuretic or other intervention orders should occur between days six through seven. The fifth step of installing the TM devices in the patient homes and instructing the patients on how to transmit data and to perform data transmission once daily for review should occur between days eight through nine. The sixth and final step of monitoring the transmitted data for timely intervention should occur no later than ten days following the initiation of the implementation to allow maximum benefit to the agency and the patient.

Flowchart

Day 1-3	Day 4-5	Day 6-7	Day 8-9	Day 10+
Rent Cardio-com devices	Register and set up software	Select staff and patients	Install devices in patient homes and educate patients on use	Monitor data and intervene appropriately with patients, providers, and staff

Data Collection Methods

The data collection methods used for the implementation and evaluation in this benchmark project are straightforward. It includes measuring pre-project implementation hospitalization and mortality rates in the target patient population and comparing the data to post-project implementation hospitalization and mortality rates in the target patient population after 3 months. All patients participating in telemonitoring are flagged in the electronic health record as a participant and care and hospital tracking is delivered as usual. At the end of the project period, a comparison will be made to determine the efficacy of the implementation. Evaluating outcomes is a critical component to deliver high quality and cost-effective healthcare (Melnyk & Fineout-Overholt, 2015).

Cost and Benefit Discussion

Several studies exist showing the benefit of initiating TM in the home care setting to reduce heart failure related hospitalization. O'Connor et al. (2016) reported, "Telehealth was associated with a reduction in all-cause 30-day readmission for one mid-sized Medicare-certified home health agency" (p. 238). For TM to be cost effective when initiated in a facility, guidelines and a clear protocol must be in place for the proper collections and translation of data. Evidence based practice guidelines can potentially improve health outcomes and organizational performance (Melnyk & Fineout-Overholt, 2015). The cost of a renting a single Cardio-com TM device is $100.00 per month per patient. This includes all software and software updates and maintenance. The cost of a single extra skilled nursed visit is billed around $150.00 per oasis visit. The cost of additional routine visits are billed at around $90.00 per visit. The cost of losing Medicare payment for a home health episode, based on the target population, is approximately $1780.00. If one patient were to be admitted to the hospital via ambulance transport and ER for HF exacerbation, the cost would be approximately $30,000.00. This is enough for one patient to have access to a Cardio-com TM device for 25 years. The other obvious benefits of this project include decreased healthcare costs outside of the agency as well as decreased burden on the healthcare system. The benefit is very clear, if one episode of payment is retracted due to HF hospitalization and negative outcomes, the agency loses enough money to fund almost six more patients to have TM devices. In the case of TM versus no TM, the benefit outweighs the cost burden.

Overall Discussion and Results

The projected results of this benchmark project are based on reviewing evidence-based literature and developing a plan to implement and utilize this benefit in professional practice. It was discovered that decreased hospitalization and mortality rates for HF patients in the home care setting is obtainable through the implementation of TM. Multiple RCT and MA across thousands of patients provide profound evidence of the projected benefit of the implementation of this benchmark project. The patient must be treated as an equal partner for success of the project implementation (Melnyk & Fineout-Overholt, 2015). When a change project is completed and guidelines are in place, it is important to develop methods for long term sustainment of the project. Even with the best plans and guidelines, the dissemination of your findings is not enough for healthcare workers to change their daily practice (Gameiro et al., 2019). It is also important that clear and concise communication be made with staff members to assist in decreasing confusion during the project. The review and consideration of this benchmark project allows professionals to be informed on the use of technology to provide evidence-based application to reduce HF related hospitalization in patients 60 years and older.

Recommendations

Based on the evidence presented in this benchmark project, TM in the home care setting to reduce HF related hospitalization and mortality should be recommended for all home health agencies treating HF patients 60 and over. The next steps include informing others of the real-world effectiveness of utilization technology to monitor chronic disease and reduce preventable hospitalizations. It is recommended that during the implementation of a project, the nurse should create an environment that is favorable for trust and respect that maximally benefits the patient and healthcare worker. In order to successfully integrate evidence-based practice into an organization, you must have the willingness to change and the tools necessary to implement the project. Organization change is a highly emotional process requiring the tools of strong leadership willingness to change (Melnyk & Fineout-Overholt, 2015). Change management requires determination and excellent communication. It is recommended that this project be implemented into organizational practice for maximal benefit to the organization and patients. Finally, it is recommended that colleagues, patients, and leadership staff adopt similar strategies to incorporate and translate evidence-based results into practice.

References

Bashi, N., Karunanithi, M., Fatehi, F., Ding, H., & Walters, D. (2017). Remote monitoring of patients with heart failure: An overview of systematic reviews. *Journal of Medical Internet Research, 19*(1), 1-14. doi: 10.2196/jmir.6571.

Boyne, J. J. J., Vrijhoef, H. J. M., Spreeuwenberg, M., Weerd, G. D., Kragten, J., & Gorgels, A. P. M. (2014). Effects of tailored telemonitoring on heart failure patients' knowledge, self-care, self-efficacy and adherence: A randomized controlled trial. *European Journal of Cardiovascular Nursing, 13*(3), 243 –252. doi: 10.1177/1474515113487464.

Delaney, C., Apostolidis, B., Bartos, S., Morrison, H., Smith, L., & Fortinsky, R. (2013). A randomized trial of telemonitoring and self-care education in heart failure patients following home care discharge. *Home Health Care Management & Practice, 25*(5), 187 –195. https://doi.org/10.1177/1084822312475137

Gallagher, B. D., Moise, N., Haerizadeh, M., Ye, S., Medina, V., & Kronish, I. M. (2017). Telemonitoring adherence to medications in heart failure patients (TEAM-HF): A pilot randomized clinical trial. *Journal of Cardiac Failure, 23*(4), 345-349. doi: 10.1016/j.cardfail.2016.11.001.

Gameiro, S., Sousa-Leite, M., & Vermeulen, N. (2019). Dissemination, implementation and impact of the ESHRE evidence-based guidelines. *Human Reproduction Open*, (3), hoz011. https://doi.org/10.1093/hropen/hoz011

Gensini, G., Alderighi, C., Rasoini, R., Mazzanti, M., & Casolo, G. (2017). Value of telemonitoring and telemedicine in heart failure management. *Cardiac Failure Review, 3*(2), 116-121. doi: 10.15420/cfr.2017:6:2.

Hindricks, G., Taborsky, M., Glikson, M., Heinrich, U., Schumacher, B., Katz, A., . . . Søgaar, P. (2014). Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME): A randomised controlled trial. *Lancet, 384*(9943), 583-590. doi: 10.1016/S0140-6736(14)61176-4.

Kitsiou, S., Paré, G., & Jaana, M. (2015). Effects of home telemonitoring interventions on patients with chronic heart failure: An overview of systematic reviews. *Journal of Medical Internet Research, 17*(3), 1-30. doi: 10.2196/jmir.4174

Kotb, A., Cameron, C., Hsieh, S., & Wells, G. (2015). Comparative effectiveness of different forms of telemedicine for individuals with heart failure (HF): A systematic review and network meta-analysis. *PloS One*, *10*(2), 1-15. doi:10.1371/journal.pone.0118681.

Melin, M., Hägglund, E., Ullman, B., Persson, H., & Hagerman, I. (2018). Effects of a tablet computer on self-care, quality of life, and knowledge: A randomized clinical trial. *The Journal of Cardiovascular Nursing, 33*(4), 336-343. doi: 10.1097/JCN.0000000000000462.

Melnyk, B. M., & Fineout-Overholt, E. (2015). *Evidence-based practice in nursing & healthcare: A guide to best practice* (3rd edition). Philadelphia, PA: Wolters-Kluwer Health.

O'Connor, M., Asdornwised, U., Dempsey, M. L., Huffenberger, A., Jost, S., Flynn, D., & Norris, A. (2016). Using telehealth to reduce all-cause 30-day hospital readmissions among heart failure patients receiving skilled home health services. *Applied Clinical Informatics, 7*(2): 238-247. doi: 10.4338/ACI-2015-11-SOA-0157

Tse, G., Chan, C., Gong, M., Meng, L., Zhang, J., Su, X. L., . . . Liu, T. (2018). Telemonitoring and hemodynamic monitoring to reduce hospitalization rates in heart failure: A systematic review and meta-analysis of randomized controlled trials and real-world studies. *Journal of Geriatric Cardiology, 15*(4), 298–309. doi: 10.11909/j.issn.1671-5411.2018.04.008.

Yun, J. E., Park, J. E., Lee, H. Y., & Park, D. A. (2018). Comparative effectiveness of telemonitoring versus usual care for heart failure: A systematic review and meta-analysis. *Journal of Cardiac Failure, 24*(1), 19-28. doi: 10.1016/j.cardfail.2017.09.006.

Zhu, Y., Gu, X., & Xu, C. (2019). Effectiveness of telemedicine systems for adults with heart failure: A meta-analysis of randomized controlled trials. *Heart Failure Reviews,* 1-13. https://doi.org/10.1007/s10741-019-09801-5

Appendix

Evaluation Table

PICOT Question: For patients 60 years and older with heart failure (P), how does the use of cardiac telemonitoring (I) compared to no cardiac telemonitoring (C) affect the risk of hospitalization (O) over a three-month period (T)?
PICOT Question Type (Circle): **Intervention** Etiology Diagnosis or Diagnostic Test Prognosis/Prediction Meaning

Caveats

1) The **only studies** you should put in these tables are the ones that **you know answer your question** after you have done rapid critical appraisal (i.e., the keeper studies)
2) Include APA reference
3) Use abbreviations & create **a legend** for readers & yourself
4) Keep your descriptions brief – there should be **NO complete sentences**
5) This evaluation is for the purpose of knowing your studies to synthesize.

Place your APA Reference here (Use correct APA reference format including the hanging indentation):

References

Bashi, N., Karunanithi, M., Fatehi, F., Ding, H., & Walters, D. (2017). Remote monitoring of patients with heart failure: An overview of systematic reviews. *Journal of Medical Internet Research, 19*(1), 1-14. doi: 10.2196/jmir.6571.

Boyne, J. J. J., Vrijhoef, H. J. M., Spreeuwenberg, M., Weerd, G. D., Kragten, J., & Gorgels, A. P. M. (2014). Effects of tailored telemonitoring on heart failure patients' knowledge, self-care, self-efficacy and adherence: A randomized controlled trial. *European Journal of Cardiovascular Nursing, 13*(3), 243 –252. doi: 10.1177/1474515113487464.

Delaney, C., Apostolidis, B., Bartos, S., Morrison, H., Smith, L., & Fortinsky, R. (2013). A randomized trial of telemonitoring and self-care education in heart failure patients following home care discharge. *Home Health Care Management & Practice, 25*(5), 187 –195. https://doi.org/10.1177/1084822312475137

Feltner, C., Jones, C. D., Cené, C. W., Zheng, Z. J., Sueta, C. A., Coker-Schwimmer, E. J., . . . Jonas, D. E. (2014). Transitional care interventions to prevent readmissions for persons with heart failure: A systematic review and meta-analysis. *Annals of Internal Medicine, 160*(11), 774-84. doi: 10.7326/M14-0083.

Gallagher, B. D., Moise, N., Haerizadeh, M., Ye, S., Medina, V., & Kronish, I. M. (2017). Telemonitoring adherence to medications in heart failure patients (TEAM-HF): A pilot randomized clinical trial. *Journal of Cardiac Failure, 23*(4), 345-349. doi: 10.1016/j.cardfail.2016.11.001.

Hindricks, G., Taborsky, M., Glikson, M., Heinrich, U., Schumacher, B., Katz, A., . . . Søgaar, P. (2014). Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME): A randomised controlled trial. *Lancet, 384*(9943), 583-590. doi: 10.1016/S0140-6736(14)61176-4.

Kitsiou, S., Paré, G., & Jaana, M. (2015). Effects of home telemonitoring interventions on patients with chronic heart failure: An overview of systematic reviews. *Journal of Medical Internet Research, 17*(3), 1-30. doi: 10.2196/jmir.4174

Kotb, A., Cameron, C., Hsieh, S., & Wells, G. (2015). Comparative effectiveness of different forms of telemedicine for individuals with heart failure (HF): A systematic review and network meta-analysis. *PloS one*, *10*(2), 1-15. doi:10.1371/journal.pone.0118681.

Melin, M., Hägglund, E., Ullman, B., Persson, H., & Hagerman, I. (2018). Effects of a tablet computer on self-care, quality of life, and knowledge: A randomized clinical trial. *The Journal of Cardiovascular Nursing, 33*(4), 336-343. doi: 10.1097/JCN.0000000000000462.

Tse, G., Chan, C., Gong, M., Meng, L., Zhang, J., Su, X. L., . . . Liu, T. (2018). Telemonitoring and hemodynamic monitoring to reduce hospitalization rates in heart failure: A systematic review and meta-analysis of randomized controlled trials and real-world studies. *Journal of Geriatric Cardiology, 15*(4), 298–309. doi: 10.11909/j.issn.1671-5411.2018.04.008.

Yun, J. E., Park, J. E., Lee, H. Y., & Park, D. A. (2018). Comparative effectiveness of telemonitoring versus usual care for heart failure: A systematic review and meta-analysis. *Journal of Cardiac Failure, 24*(1), 19-28. doi: 10.1016/j.cardfail.2017.09.006.

Zhu, Y., Gu, X., & Xu, C. (2019). Effectiveness of telemedicine systems for adults with heart failure: A meta-analysis of randomized controlled trials. *Heart Failure Reviews,* 1-13. https://doi.org/10.1007/s10741-019-09801-5

Citation: (i.e., author(s), date of publication, & title)	**Conceptual Framework**	**Design/ Method**	**Sample/ Setting**	**Major Variables Studied and Their Definitions**	**Measurement of Major Variables**	**Data Analysis**	**Study Findings**	**Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses])**
Author, Year, Title	**Theoretical basis for study** **Qualitative Tradition**		**Number, Characteristics, Attrition rate & why?**	**Independent variables (e.g., IV1 =** **IV2 =)** **Dependent variables (e.g., DV =)**	**What scales were used to measure the outcome variables (e.g., name of scale, author, reliability info [e.g.,**	**What stats were used to answer the clinical question (i.e., all stats**	**Statistical findings or qualitative findings (i.e., for every statistical test you have in the data analysis column, you**	**• Strengths and limitations of the study** **• Risk or harm if study intervention or findings implemented** **• Feasibility of use in your practice** **• Remember: level of evidence (See Melnyk & Fineout-Overholt, pp. 32-33) + quality of evidence = strength of evidence & confidence to act**

					Cronbach alphas])	**do not need to be put into the table)**	**should have a finding)**	• **Use the USPSTF grading schema http://www.ahrq.gov/clinic/3rduspstf/ratings.htm**
Bashi et al. 2017 Remote monitoring of patients with heart failure: An overview of systematic reviews.	NR	SR	52,375 P 296 RCT MA 48-83 NYHA I-IV EF <45% >6 month intervention	IV 1 TM IV2 UC DV Reduced HF mortality and hospitalization risk	NR	OR	Mortality RR, 0.66 95% CI 0.54-0.81 P<.001 TM 24 hours HR 0.76 95% CI 0.49-1.18 TM office hours HR 0.62 95% credible 0.42-0.89 OR 0.53	Strengths SR of RCT DC of TM and UC Diverse interventions Limitations Some evidence not focused on less common TM methods NSR TM technique feasible for practice use Intervention PICOT/SR level I evidence Quality of evidence strong USPSTF Grade B High level of certainty
Boyne et al. 2014 Effects of tailored telemonitoring on heart failure patients' knowledge, self-care, self-efficacy and adherence: A randomized controlled trial	NR	RCT	382 P 197 TM 185 UC Age >18 MA 71 >1 Episode fluid retention requiring diuretics NYHA II-IV MEF 38 % AR 21 No FU 3 hospitals South of Netherlands October 2007 December 2008	IV 1 TM IV 2 UC DV Improve self-care abilities and sense of self-efficacy	BEES Barnason et al. CA 0.837 DHFKS Van der Wal et al. CA 0.62 EHFSCB Jaarsma et al. CA 0.80	STT MWU	Disease-specific knowledge TM 12.6 C 12.3 *p* = 0.09 Self-care TM 18.9 C 20.9 *p* = 0.001 Self-efficacy TM 53.2 C 51.1 *p* = 0.024 Mean knowledge score TM 12.6 C 12.3 *p* = 0.09 Overall compliance TM 92.3% IQR 84.7–94.9	Strengths RCT *n* calculation based on HF admissions DC of TM and UC Limitations QQD NSR TM technique feasible for practice use Intervention PICOT/RCT level II evidence Quality of evidence strong USPSTF Grade C Moderate level of certainty
Delaney et al. 2013 A randomized trial of telemonitoring and self-care	Self-care management	RCT	100 P 50 TM 50 UC Age >21 MA 80 Discharged to home health	IV 1 TM IV 2 UC DV Decreased hospitalization, improved	DHFKS Van der Wal et al. CA 0.62	ANOVA PCS LR	MLHF scores TM (mean = 32.1; SD = 15.3, *p* = .004) C (mean = 42.4; SD 16.7)	Strengths RCT DC of TM and UC Racial/ethnic diversity Limitations Short FU time NSR

education in heart failure patients following home care discharge			NYHA III, IV AR 7 Died Refused installation Dropped out Home care agency in Connecticut 90 days	QOL, increased HF knowledge at 90 days following home care discharge			HF knowledge TM 11.78 (1.8) 13.10 (2.2) *F* = 6.40 *β* = .225 C 11.03 (2.4) 11.37 (1.9) *p* = .013 *p* = .039 QOL C 42.94 (16.2) 42.42 (16.7) *p* = .004 *p* = .011 TM 41.57 (18.3) 32.10 (15.3) *F* = 8.66 *β* = –.278	TM technique feasible for practice use Intervention PICOT/RCT level II evidence Quality of evidence strong USPSTF Grade C Moderate level of certainty
Feltner et al.	NR	SR	15,999 P 47 RCT MA 70 NYHA I-IV EF <45% >6 month intervention	IV 1 TM IV2 UC DV Reduced HF mortality and hospitalization risk	NR	RR	Home visits vs. UC RR, 0.34 95% CI 0.19 to 0.62	Strengths SR of RCT DC of TM and UC Diverse interventions Limitations Usual care not adequately described NSR TM technique feasible for practice use Intervention PICOT/SR level I evidence Quality of evidence strong USPSTF Grade B High level of certainty
Gallagher et al. 2017 Telemonitoring adherence to medications in heart failure patients (TEAM-HF): A pilot randomized clinical trial	NR	RCT	40 P 20 TM 20 UC Age >21 MA 64 Discharged on loop diuretic NYHA I, II, or III MEF 25 % AR 4 No device use New York–Presbyterian Hospital	IV 1 TM IV 2 UC DV Loop diuretic adherence after discharge	NR	MWU PCS FET IQR	10 P readmitted < 30 days Adherent to diuretics TM 10 C 9 *p* = 0.49 Correct dosing TM 81.8 C 73.3 *p* = 0.41 IQR 47–94% Attended 30 day FU TM 19 C 16 *p* = 0.34	Strengths RCT DC of TM and UC New study type Racial/ethnic diversity Limitations Short FU time No confirmation of ingestion Nonadherent patients not targeted Privacy concerns NSR TM technique feasible for practice use Intervention PICOT/RCT level II evidence Quality of evidence strong USPSTF Grade C Moderate level of certainty

			December 2014 to August 2015					
Hindricks et al. 2014 Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME): A randomised controlled trial	NR	RCT	664 P 333 TM 331 UC Age >18 MA 65.5 Chronic HF >3 months NYHA II, or III MEF 26 % AR 30 TP Died Lost to follow-up WC 36 tertiary clinical centres, in Australia, Europe, and Israel	IV 1 TM IV 2 UC DV Improved clinical outcomes Decreased all cause mortality	NR	MWU PCS CR KMM OR	Hospital admissions TM 44 C 47 1-year cardiovascular mortality TM 2.7% C 6.8% Worsening NYHA functional class TM 29 C 35 Worsening composite clinical score TM 63 C 90 95% CI	Strengths RCT DC of TM and UC Moderate sample size Limitations Inability to mask patients/investigators to treatment allocation Medium-term length of follow-up Did not enforce standardized treatment after TM observations NSR TM technique feasible for practice use Intervention PICOT/RCT level II evidence Quality of evidence strong USPSTF Grade C Moderate level of certainty
Kitsiou et al. 2014 Effects of home telemonitoring interventions on patients with chronic heart failure: An overview of systematic reviews.	NR	SR	15 SR MA 48-83 NYHA I-IV EF <45% >6 month intervention	IV 1 TM IV2 UC DV Reduced HF mortality and hospitalization risk	NR	NR	OR 0.60 CI 95% Improvements in HF hospitalizations HR 0.70 95% credible interval Crl 0.34-1.5	Strengths SR of RCT DC of TM and UC Diverse interventions Limitations Some evidence not focused on less common TM methods NSR TM technique feasible for practice use Intervention PICOT/SR level I evidence Quality of evidence strong USPSTF Grade B High level of certainty
Kotb et al. 2015 Comparative effectiveness of different forms of telemedicine for individuals with heart failure	NR	SR META	10,193 P 30 RCT MA 65 Majority male NYHA I-IV EF <45% >6 month intervention	IV 1 TM IV2 UC DV Reduced HF related death and hospitalization	NR	OR	Mortality TM 0.53 OR HF Hospitalization TM 0.64 OR	Strengths SR of RCT META DC of TM and UC >6 month FU Limitations Available evidence not focused on less common methods NSR TM technique feasible for practice use

(HF): A systematic review and network meta-analysis								Intervention PICOT/SR level I evidence Quality of evidence strong USPSTF Grade B High level of certainty
Melin et al. 2018 Effects of a tablet computer on self-care, quality of life, and knowledge: A randomized clinical trial	NR	RCT	72 P MA 75 NYHA III Acute HF or FU 4 weeks AR 14 Died Withdrew consent 3 university hospitals in Stockholm Sweden	IV 1 TM IV2 UC DV Improved self-care behavior, QOL, increased HF knowledge, reduced hospital days	DHFKS Van der Wal et al. CA 0.62 EHFSCB Jaarsma et al. CA 0.80	MWU IQR	Self Care TM 16.5 IQR 12-22 C 23.5 IQR 18.8-30.0 *P* < .05 QOL TM 72.7 IQR 50.8-87.9 C 51.8 IQR 40.9-62.8 *P* < .05 HF hospitalization TM 6.9 (6 months) C 9.6 (6 months)	Strengths RCT DC of TM and UC Sustained results at 6 months Limitations Increased AFIB in C NSR TM technique feasible for practice use Intervention PICOT/RCT level II evidence Quality of evidence strong USPSTF Grade C Moderate level of certainty
Tse et al. 2018 Telemonitoring and hemodynamic monitoring to reduce hospitalization rates in heart failure: A systematic review and meta-analysis of randomized controlled trials and real-world studies	NR	SR META	31,501 P 55 RCT 61% male MA 68 PubMed Cochrane Library FU duration 11 months	IV 1 TM IV2 UC DV Reduced HF hospitalization short and long term	JS Jadad et al. NCAR	PCS CQT	TM reduced hospitalization HR 0.73 95% CI 0.65-0.83 *P* < 0.0001 HF hospitalization short term HR = 0.77 0.65-0.89 *P* < 0.01 HF hospitalization long term HR = 0.73 95% CI 0.62-0.87 *P* < 0.0001	Strengths SR of RCT META DC of TM and UC Limitations Lack of comparison of TM to HDM Heterogeneity for HR for effects of TM on hospitalization NSR TM technique feasible for practice use Intervention PICOT/SR level I evidence Quality of evidence strong USPSTF Grade B High level of certainty
Yun et al. 2018 Comparative effectiveness of telemonitoring versus usual care for heart failure: A systematic review and	NR	SR META	9582 P MA 67.7 NYHA III-IV Ovid-Medline Ovid-Embase Cochrane Library USA	IV 1 TM IV2 UC DV Reduced HF mortality and hospitalization risk	NR	CQT	HR mortality RR 0.68 95% CI 0.50–0.91 QOL Depression −36% *P* < .0001 Anxiety −38% *P* <.0001	Strengths SR of RCT META DC of TM and UC Limitations C group composition varied No total duration of hospitalization data NSR TM technique feasible for practice use

meta-analysis			Europe				Medication adherence RR 0.73 95% CI 0.61–0.87	Intervention PICOT/SR level I evidence Quality of evidence strong USPSTF Grade B High level of certainty
Zhu et al. 2019 Effectiveness of telemedicine systems for adults with heart failure: A meta-analysis of randomized controlled trials	NR	META	10,981 P 29 RCT FU 1-36 months NYHA I/IV EF <45% PubMed MEDLINE EMBASE Cochrane Library	IV 1 TM IV2 UC DV Reduced HF hospital admissions Reduced HF mortality	NR	OR CQT	TM reduced hospitalization OR 0.82 95% CI 0.73–0.91 P=0.0004 TM reduced HF hospitalization OR 0.83 95% CI 0.72–0.95 P=0.007 TM reduced mortality OR 0.75 95% CI 0.62–0.90 P=0.003	Strengths META DC of TM and UC Limitations Some trials underpowered Some endpoint data unavailable NSR TM technique feasible for practice use Intervention PICOT/META level I evidence Quality of evidence strong USPSTF Grade B High level of certainty

Legend:

(AFIB) atrial fibrillation
(ANOVA) analysis of variance
(AR) attrition rate
(BEES) Barnason Efficacy Expectation Scale
(C) control
(CA) Cronbach’s alpha
(CI) confidence interval
(CQT) Cochran's Q test
(CR) Cox regression
(DC) direct comparison
(DHFKS) Dutch HF Knowledge Scale
(EF) ejection fraction
(EHFSCB) European Heart Failure Self-care Behaviour scale
(FET) Fisher's exact test
(FU) follow up
(HDM) hemodynamic monitoring
(HF) heart failure
(HR) hazard ratio
(IQR) interquartile population range
(JD) Jadad scale
(KMM) Kaplan–Meier method

(LR) linear regression
(MA) median age
(MEF) median ejection fraction
(META) meta-analysis
(MLHF) Minnesota living with heart failure questionnaire
(MR) meta-regression
(MWU) Mann–Whitney U test
(*n*) sample size
(NCAR) no Cronbach's alpha reported
(NR) none reported
(NSR) no significant risks
(NYHA) New York Heart Association
(OR) odds ratio
(*p*) p-value
(P) participants
(PCS) Pearson's chi-squared
(PR) peer reviewed
(PRISMA) preferred reporting items for systematic reviews and meta-analyses
(QQD) quantitative questionnaire design
(QOL) quality of life
(RCT) randomized control/clincal trial
(RR) risk ratio
(SD) standard deviation
(SR) systematic review
(STT) student t-test
(TM) telemonitoring
(TP) terminated prematurely
(UC) usual care
(USA) United States of America
(WC) withdrew consent

***Prompts for each column – **please do not repeat the headings, just provide the data**