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**Impact of Telemedicine on Heart Failure Readmissions and Mortality: A Literature
Review**

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N695: Alternate Plan Paper

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Abstract

Background: Heart failure is a chronic condition that commonly results in frequent hospitalizations and increases risk of mortality (Kotb et al., 2015; Ong et al., 2016; Pekmezaris et al., 2018). In addition, heart failure places a significant burden on healthcare costs and utilization of resources (Hale et al., 2016; Kotb et al., 2015; Ong et al., 2016). Measures to reduce heart failure readmissions, mortality, and overall costs are needed. Telemedicine interventions may be beneficial in the management of heart failure; however, the current research provides unclear and inconclusive findings in regard to the effectiveness of telemedicine interventions on heart failure readmissions and mortality (Kraai et al., 2016). **Aim:** The aim of this literature review is to evaluate the impact of telemedicine interventions on heart failure readmissions and mortality. **Methods:** A literature review was conducted using five healthcare-related databases for data collection. A systematic search process was employed to extract literature that was relevant and answered the identified clinical question using keywords and specific inclusion and exclusion criteria. A total of 10 studies met inclusion criteria for critical appraisal. **Results:** Study outcomes related to heart failure readmissions and mortality were mixed. Limitations of the studies as well as direction for future studies were identified. **Conclusions:** Synthesized findings from this literature review identify that telemedicine interventions may improve outcomes in heart failure patients. However, further research studies are warranted to evaluate the efficacy of telemedicine on heart failure outcomes.

Keywords: heart failure, telehealth, telemonitoring, telemedicine, readmission, mortality, intervention, outcome, 30 day

Impact of Telemedicine on Heart Failure Readmissions and Mortality: A Literature Review

Heart failure is a chronic condition leading to progressive, impaired cardiac function (Kotb et al., 2015; Pekmezaris et al., 2018). Individuals with heart failure are at risk for frequent hospitalizations and have an increased risk of mortality (Kotb et al., 2015; Ong et al., 2016; Pekmezaris et al., 2018). The negative impact of heart failure on healthcare costs and utilization is also a rising concern (Hale et al., 2016; Kotb et al., 2015; Ong et al., 2016). Issues with accessibility, poor transitions of care and monitoring post-hospitalization are factors associated with this increased burden on the healthcare system (Koehler et al., 2018; Ong et al., 2016). Interventions aimed at reducing readmissions and mortality are warranted and an essential component of heart failure management (Koehler et al., 2018). Technological advances have given rise to innovative measures utilized in the healthcare setting in an effort to improve health outcomes. Numerous telemedicine interventions are available and are currently being used in the management of various illnesses including heart failure. These measures have been implemented in an effort to reduce disease progression and subsequent hospitalization through frequent monitoring and increased follow up (Koehler et al., 2018; Kotb et al., 2015; Pedone et al., 2015). The utilization of telemedicine in heart failure provides a means to remotely care for heart failure patients; therefore, increasing the timeliness of care while also improving the quality of the care provided (Koehler et al., 2018). Research has shown a potential reduction in heart failure-related hospitalizations, morbidity, and mortality through the use of telemonitoring programs (Hale et al., 2016; Kotb et al., 2015; Ong et al., 2016; Pedone et al., 2015). Additionally, it is suggested that

telemedicine technologies may reduce overall costs related to heart failure (Kotb et al., 2015; Ong et al., 2016; Pedone et al., 2015). However, findings from current research studies are often inconsistent or inconclusive (Koehler et al., 2018; Long et al., 2017; Pedone et al., 2015). Moreover, there have been no significant improvements in health outcomes among heart failure patients despite these technological advancements (Son et al., 2020). Innovative methods to improve the care of patients with heart failure, reduce hospital readmissions, and reduce overall mortality are necessary. Further research focusing on interventions for heart failure management and dissemination of findings are needed to guide healthcare providers to best care for heart failure patients. The purpose of this literature review is to identify and synthesize findings related to the impact of telemedicine interventions on heart failure readmissions and mortality. Another goal of this review is to identify findings that can be used to help guide current and future practice related to heart failure management.

Background

Prevalence of Heart Failure

As many as 6 million Americans have been diagnosed with heart failure (Hale et al., 2016; Long et al., 2017; Ong et al., 2016; Pekmezaris et al., 2018). Moreover, the overall prevalence of heart failure is increasing, with an additional 555,000 individuals being diagnosed every year (Hale et al., 2016; Long et al., 2017; Ong et al., 2016; Pekmezaris et al., 2018; Son et al., 2020). Additionally, the total number of individuals diagnosed with heart failure is projected to increase 46% by the year 2030 (Son et al., 2020). Older individuals, especially, have a higher incidence of heart failure, with nearly

10 out of 1,000 adults aged 65 and older diagnosed (Long et al., 2017; Pekmezaris et al., 2018; Son et al., 2020).

Heart Failure Prognosis

Heart failure patients are frequently hospitalized and are six times more likely to be hospitalized compared to those without heart failure (Long et al., 2017; Ong et al., 2016). Additionally, heart failure patients who are discharged are frequently readmitted (Hale et al., 2016; Ong et al., 2016). Research demonstrates that 13% of discharged patients are readmitted within 15 days, 25% are readmitted within 30 days, and almost 50% are readmitted within six months of hospital discharge (Hale et al., 2016). Individuals with heart failure are also at an increased risk of mortality, with one in nine deaths being attributed to heart failure (Hale et al., 2016; Kotb et al., 2015; Ong et al., 2016). Lastly, individuals aged 65 and older account for 80% of heart failure hospitalizations and 90% of deaths related to heart failure (Son et al., 2020).

Burden on Costs and Healthcare Utilization

Heart failure has a tremendous impact on healthcare utilization and expenditure (Pekmezaris et al., 2018). Additionally, it has been identified as the leading cause of hospital admissions, especially among adults 65 years of age and older (Hale et al., 2016; Long et al., 2017). The annual cost of managing heart failure is over \$100 billion dollars (Pekmezaris et al., 2018). Moreover, roughly 34% of Medicare spending is targeted toward heart failure (Long et al., 2017). As a result of the Affordable Care Act, hospitals may experience decreased payments from the Centers for Medicare and Medicaid Services as a result of excessive readmissions related to heart failure (Long et al., 2017; Ong et al., 2016). Furthermore, costs related to heart failure are expected to trend upward,

with hospitalizations being a major contributor (Hale et al., 2016; Long et al., 2017; Pekmezaris et al., 2018). However, current methods aimed at reducing hospital readmissions have proven challenging (Koehler et al., 2018). As a result of the negative impact of heart failure on costs and healthcare utilization, identification of specific interventions are necessary to reduce this burden on the healthcare system (Long et al., 2017; Pekmezaris et al., 2018).

Heart Failure Management

Self-management is a complex process and a major component in chronic heart failure management (Hale et al., 2016; Long et al., 2017). Patients are required to engage in self-care behaviors including frequent monitoring of their weight, recording symptoms, adhering to medication regimens, and modifying their lifestyle to attain positive health outcomes (Son et al., 2020). Research findings suggest that medication adherence is directly related to heart failure outcomes (Hale et al., 2016). Poor medication adherence ultimately contributes to increased risk for hospitalization and mortality, and increased costs (Hale et al., 2016). Many factors contribute to poor medication adherence in heart failure patients including complex medication regimens and memory issues among older adults (Hale et al., 2016). Measures to improve medication adherence, self-care, and self-management are necessary to improve outcomes (Hale et al., 2016). Many telehealth interventions that have been utilized in the management of heart failure may lead to a reduction in hospital readmissions and overall mortality (Hale et al., 2016). However, specific telemedicine interventions that can improve these outcomes need to be identified.

Definitions

Telehealth. Telehealth encompasses delivering healthcare services through technological devices (Hale et al., 2016; Pekmezaris et al., 2018). It can be useful for communicating, providing education, coordinating care, and enhancing disease self-management and self-care (Hale et al., 2016; Pekmezaris et al., 2018).

Telemedicine. Telemedicine incorporates remote care delivery via technology in order to provide more accessible healthcare, improve the quality of care provided, and reduce healthcare costs (Hale et al., 2016). These interventions may include structured telephone support, telemonitoring systems, video monitoring, medication dispensers, Bluetooth capable devices that monitor biometrics, and telemedicine systems that allow ECG transmissions (Kotb et al., 2015; Long et al., 2017).

Telemonitoring. Telemonitoring is a telehealth intervention that allows for remote monitoring of various measurements from a centralized location to the healthcare setting (Hale et al., 2016; Pekmezaris et al., 2018). These measurements can include weight, vital signs, and patient-reported symptoms (Hale et al., 2016). Remote monitoring interventions provide a means to adjust medication regimens, provide patient education, and detect signs of deterioration earlier on (Koehler et al., 2018).

Clinical Phenomenon of Interest

The author of this literature review cultivated a spirit of inquiry in which a clinical phenomenon of interest was identified (Melnik & Fineout-Overholt, 2019). The author identified a wide range of telemedicine technologies used in the management of heart failure that appear promising (Pekmezaris et al., 2018). However, their effectiveness in reducing heart failure readmissions and mortality remains unclear (Koehler et al., 2018; Long et al., 2017). The clinical phenomenon of interest specific to this literature review is

the use of telemedicine and its role in the management of heart failure. Of particular interest, is the impact of telemedicine interventions on heart failure readmissions and mortality.

Clinical Question

A clinical question was developed for this literature review based on the clinical phenomenon of interest pertaining to the impact of telemedicine interventions on heart failure outcomes. The health outcomes evaluated were heart failure-related readmissions and mortality. The clinical question was formatted and structured in PICOT format (P=population, I=intervention, C=comparison, O=outcome, T=time) outlined by Melnyk and Fineout-Overholt (2019) in an effort to obtain relevant evidence from the current literature. The clinical PICO(T) question posed for this literature review was as follows:

In adult heart failure patients (P), does the use of telemedicine interventions (I) compared to standard care without the use of telemedicine interventions (C) impact hospital readmissions and overall mortality (O)?

Clinical Significance for Advanced Practice Providers

Self-management in heart failure is a complex process. Advanced practice providers have a key role in assisting heart failure patients to achieve positive health outcomes as they work closely with this patient population. However, there are several factors that may hinder effective heart failure management including accessibility and poor care transitions post-hospitalization (Long et al., 2017; Ong et al., 2016).

Additionally, heart failure has been identified as a significant public health issue resulting in frequent hospitalizations and increased mortality rates (Pekmezaris et al., 2018). The burden on costs and healthcare utilization is also a rising concern. Changes to

reimbursements and penalties related to excessive readmissions in heart failure patients have mandated healthcare providers to identify effective measures to lower readmission rates (Long et al., 2017; Ong et al., 2016; Pekmezaris et al., 2018). These issues require advanced practice providers to be knowledgeable about best practices to reduce heart failure readmissions, mortality rates, and healthcare costs and utilization while improving the overall quality of care for heart failure patients. Therefore, evaluating the effectiveness of telemedicine on heart failure outcomes can assist in guiding current practice (Long et al., 2017). Additionally, previous studies have identified a potential reduction in hospital readmissions among heart failure patients and mortality through specific telemedicine interventions (Ong et al., 2016). The use of various telemedicine technologies could prove valuable in standardizing care among heart failure patients, improving care transitions, increasing access to care, and decreasing hospital readmission rates (Long et al., 2017). Thus, the purpose of this literature review is to identify telemedicine interventions that may be effective in improving health outcomes among heart failure patients.

Methods

Search Strategies

A total of five databases related to medicine, nursing, allied health, and healthcare were selected for this literature review. Databases included in the search included PubMed, CINAHL Plus (with full text), Nursing and Allied Health Database (Formerly ProQuest Nursing and Allied Health Source), Academic Search Premier (ASP), and the Cochrane Database of Systematic Reviews. Date ranges included in the database searches were limited to publication dates between 2015 and 2020. Refer to Table A1 in the

Appendix for further information on the databases utilized in the search process and the general subjects covered by the databases selected. The search process was restricted to articles that were free, full-text, from scholarly academic journals, were peer-reviewed, in the English language, and included the adult (18+) patient population. Refer to Table A1 in the Appendix for additional search restrictions employed per database.

Data Abstraction Process

A systematic and comprehensive search of the literature was conducted utilizing the previously mentioned databases. The literature was searched on November 14th, 2020 and November 15th, 2020 for the most current evidence that would answer the clinical PICO(T) question posed (Melnyk & Fineout-Overholt, 2019). Keywords and keyword combinations were entered into each database using the Boolean operators. The keywords and keyword combinations included in the search process were “heart failure” AND “telehealth”, “heart failure” AND “telehealth” OR “telemonitoring” OR “telemedicine” AND “readmission” AND “mortality”, “heart failure” AND “telehealth” AND “readmission” AND “mortality”, “heart failure” AND “telemedicine” AND “intervention” AND “readmission” AND “mortality” AND “outcome”, and “heart failure” AND “telemedicine” AND “intervention” AND “readmission” AND “30 day” AND “mortality” AND “outcome”. Initial hits from the search were substantial. Thus, search results from each database were further narrowed to a manageable number of articles utilizing these specific keywords and keyword combinations. Hits of less than 50 articles as a result of these keywords and keyword combinations were further reviewed for inclusion or exclusion based on the criteria used for this literature review. Duplicate articles were removed. Refer to Table A2 in the Appendix for detailed information on the

data abstraction process and the results from each database using these keywords and keyword combinations.

Literature Review Process

A total of 15 articles were reviewed for inclusion and exclusion criteria from PubMed, 48 from CINAHL, 45 from Nursing and Allied Health, 43 from Academic Search Premier, and two articles from the Cochrane Database of Systematic Reviews. Specific details related to each study were thoroughly reviewed including study purpose, population, setting, sample size, design, level of evidence, variables, instruments, interventions as well as primary and secondary outcomes. Studies were limited to either level I or level II evidence based on the hierarchy of evidence (Melnyk and Fineout-Overholt, 2019). Studies that were directly related to the targeted heart failure population, incorporated the use of telemedicine modalities, and addressed heart failure-related hospital readmissions and mortality rates were included in this literature review. Studies were excluded if the heart failure population was not the population of interest and if outcomes were evaluated among multiple patient populations or disease processes such as COPD. Studies that did not specifically evaluate the impact of telemedicine on heart failure readmissions and mortality as a primary or secondary outcome were also excluded. Additional studies were excluded if they did not meet the criteria for level I or II evidence (Melnyk & Fineout-Overholt, 2019). Furthermore, studies were excluded if they involved study designs or study protocols. Refer to Table A3 in the Appendix for further details pertaining to the included and excluded studies and the author's rationale for inclusion or exclusion.

Methodological Assessment

A total of 10 articles were yielded from the search process for critical appraisal. The studies included five randomized controlled trials. There were two systematic reviews and four studies that were a combined systematic review and meta-analysis. Studies that were either level I or level II evidence and pertinent to the clinical PICO(T) question were retained and evaluated (Melnyk & Fineout-Overholt, 2019). Refer to Table A4 in the Appendix for detailed information on the types of studies included in this literature review.

Overall, there were no identified issues with bias within the search process. Despite using strategic search methods, it is possible that articles relevant to this literature review were not identified due to the specific keywords employed in the search process. The keywords utilized may have limited the search results as there are a variety of terms used to describe telemedicine as well as a multitude of telemedicine interventions available that may not have been specified in the keywords and keyword combinations utilized.

Literature Review

The following literature review will provide a synthesis of the current available evidence pertaining to the clinical phenomenon of interest and answering the clinical PICO(T) question posed. This literature review will identify the characteristics of the studies included and synthesize findings related to the impact of telemedicine in heart failure management and health outcomes. More specifically, this literature review will identify findings related to the effect of telemedicine interventions in reducing heart failure readmissions and mortality.

Study Characteristics

As previously outlined, there were a total of 10 studies that met the eligibility criteria for inclusion and were critically appraised for this literature review. The studies yielded were level I or level II evidence and were published between 2015 and 2020. There were five randomized controlled trials, two systematic reviews, and four combined systematic reviews and meta-analyses. Sample sizes among the studies included in this literature review ranged from 25 to 51,014. There were seven studies with sample sizes over 1,400. Only three of the studies had sample sizes of less than 200.

The included studies evaluated a form of telemedicine intervention in adult (18+) patients with heart failure in the outpatient setting. Among these studies, four of them evaluated the use of a non-invasive telemonitoring system that transmitted patient data to the healthcare team (Koehler et al., 2018; Kraai et al., 2016; Long et al., 2017; Pekmezaris et al., 2018). There were two studies that evaluated the use of structured telephone support and non-invasive home telemonitoring devices (Inglis et al., 2015; Pedone et al., 2015). Son et al. (2020) utilized mobile phone-based interventions, which included voice call, telemonitoring, and short message services (SMS). A MedSentry remote medication monitoring system was evaluated in heart failure management in the Hale et al. (2016) study. Kotb et al. (2015) evaluated the use of telephone support with telemonitoring, video monitoring, and electrocardiogram (ECG) monitoring. The final study evaluated the effectiveness of health coaching telephone calls along with telemonitoring (Ong et al., 2016).

The primary end outcomes of a majority of the studies included all-cause hospitalizations, heart failure-related hospitalizations, all-cause mortality, and heart failure-related mortality (Hale et al., 2016; Inglis et al., 2015; Koehler et al., 2018; Kotb

et al., 2015). Ong et al. (2016) assessed all-cause readmissions within 30 and 180 days from hospital discharge, all-cause mortality at 30 and 180 days, and quality of life at 30 and 180 days. Long et al. (2017) was the only other study that evaluated the impact of telemonitoring on 30-day hospital readmissions. Pekmezaris et al. (2018) specifically assessed all-cause mortality at 180 days and 365 days, all-cause hospitalizations at 90 and 180 days, and heart failure-related hospitalizations at 180 days. Pedone et al. (2015) also assessed hospital readmissions and mortality at 180 days. In the Koehler et al. (2018) study, percent of days lost as a result of an unplanned admission and mortality were also evaluated. Additional outcomes assessed in the Inglis et al. (2015) study included hospital length of stay (LOS), health-related quality of life (HRQL), heart failure knowledge and self-care, acceptability, and costs. Emergency department (ED) visits, medication adherence, and HRQL were additional outcomes assessed in the Hale et al. (2016) study. Furthermore, Kraai et al. (2016) evaluated the total and duration of hospital admissions as well as the number of outpatient visits to the heart failure clinic, change in HRQL, and cost analyses.

Synthesis of Research on Hospitalization and Readmissions

Hale et al. (2016) demonstrated a significant decrease in the rate of all-cause hospitalizations and hospital LOS in the intervention arm compared to the control. However, there were no differences noted in regard to ED visits as well as heart failure-related and non-heart failure-related hospitalizations (Hale et al., 2016). In the Inglis et al. (2015) systematic review, both non-invasive telemonitoring and structured telephone support lowered heart failure-related hospitalizations; however, there was no reduction in the risk of all-cause hospitalizations. Koehler et al. (2018) found that the remote

monitoring group had a lower percentage of days lost related to unplanned heart failure-related readmissions. In the Kotb et al. (2015) systematic review and meta-analysis, there was no significant reduction in all-cause hospitalization among the intervention groups. However, there was a significant reduction in heart failure-related hospitalizations among the intervention groups, which included structured telephone support, telemonitoring, and telemedicine along with ECG transmission (Kotb et al., 2015). Additionally, reductions in hospitalizations were noted in the Pedone et al. (2015) study through the use of a physician-led telemonitoring program.

In the systematic review and meta-analysis by Son et al. (2020), there were no significant reductions in hospital readmissions using mobile phone-based interventions. However, there was a significant reduction in hospital LOS (Son et al., 2020). The IN TOUCH study by Kraai et al. (2015) did not show significant benefits from the use of telemonitoring in preventing heart failure-related readmissions. The Long et al. (2017) systematic review showed mixed results. There were some differences noted regarding readmissions in some of the studies. However, these studies lacked an adequate sample size (Long et al., 2017). In the BEAT-HF study, there was no significant difference in all-cause 30-day or 180-day readmissions using health coaching, telephone calls in addition to telemonitoring (Ong et al., 2016). All-cause hospitalizations at 90 and 180 days were not impacted by telemonitoring in the Pekmezaris et al. (2018) systematic review and meta-analysis. Additionally, Pekmezaris et al. (2018) identified that heart failure-related hospitalizations at 180 days were not significantly reduced in the intervention group.

Synthesis of Research on Mortality

In the Inglis et al. (2015) systematic review, all-cause mortality was lowered using non-invasive telemonitoring and structured telephone support. The TIM-HF2 study by Koehler et al. (2018) demonstrated a decreased percentage of days lost as a result of all-cause mortality in the remote monitoring group compared to the standard care group. However, no significant difference was noted in the percentage of days lost as a result of heart failure-related mortality (Koehler et al., 2018). The systematic review and meta-analysis by Kotb et al. (2015) identified that both structured telephone support as well as telemonitoring significantly lowered the risk of all-cause mortality among the intervention groups; however, this was more notable among the telemonitoring group. There were no significant differences noted between the groups using the other telemedicine interventions on all-cause mortality (Kotb et al., 2015). In the Long et al. (2017) systematic review, there was a 50% reduction in mortality among the telemonitoring group in one of the studies included in the review. The systematic review and meta-analysis by Pekmezaris et al. (2018) noted a 40% decrease in 180-day all-cause mortality in the telemonitoring group. Additionally, two studies demonstrated a 61% reduction in heart failure-related mortality at 180 days (Pekmezaris et al., 2018). However, there was no significant reduction in all-cause mortality at 365 days (Pekmezaris et al., 2018). The physician-led, telemonitoring program in the Pedone et al. (2015) study also demonstrated effectiveness in reducing 180-day mortality. Moreover, the systematic review and meta-analysis by Son et al. (2020) found a reduction in risk of mortality using mobile phone-based interventions; however, pooled results demonstrated low heterogeneity. The IN TOUCH study by Kraai et al. (2015) did not find any significant benefits related to all-cause mortality in the telemonitoring group. Lastly,

there were no differences in 180-day all-cause mortality noted between the groups in the BEAT-HF study (Ong et al., 2016).

Quality Indicators and Strength of Search

The search methods employed for this literature review were comprehensive in nature. Search results were reviewed for level of evidence and critically appraised for inclusion in this review. The research articles utilized for this review were limited to peer reviewed articles from scholarly, academic journals. Furthermore, articles were limited to level I or II evidence according to the hierarchy of evidence (Melnik and Fineout-Overholt, 2019).

Gaps and Limitations

Lack of an adequate sample size was a common theme identified in many of the studies that were included (Kraai et al., 2016). Hale et al. (2016) mention issues with poor recruitment, thus, leading to small sample size. Additionally, poor adherence to the telemonitoring interventions was noted among participants in the BEAT-HF study (Ong et al., 2016). In the study by Hale et al. (2016), significant differences in baseline characteristics consisting of the New York Heart Association (NYHA) classification of heart failure and HRQL were noted among the participants. Another gap identified in the literature was the exclusion of individuals likely at increased risk for 30-day readmissions (Long et al., 2017). Additionally, the subpopulation(s) of heart failure patients that would most benefit from telemedicine interventions have been ill-defined (Kotb et al., 2015). Long et al. (2017) mention the inconsistencies and lack of standardized design protocols among telemonitoring systems leading to poor intervention fidelity. Many previous studies also only broadly assess the effects of telemedicine interventions in comparison to

usual care (Kotb et al., 2015). Additionally, the available research comparing telemedicine interventions is limited (Kotb et al., 2015). Moreover, studies are consistently focused on telephone support and telemonitoring interventions in the heart failure population with research lacking in other areas such as video monitoring and ECG monitoring (Kotb et al., 2015). Long et al. (2017) specifically mentions the lack of research evaluating the impact of telemedicine interventions on 30-day readmission rates. A comparison of the cost-effectiveness between the various telemedicine interventions is also not well known (Kotb et al., 2015). Lastly, the long-term clinical significance of telehealth interventions on heart failure readmissions and hospitalizations is poorly understood (Hale et al., 2016; Kotb et al., 2015).

Discussion

The findings from this review demonstrated mixed results. Hale et al. (2016) noted a significant reduction in all-cause hospitalizations as well as decreased hospital LOS in the intervention group compared to the standard care group with the use of the MedSentry medication monitoring system. However, Hale et al. (2016) also noted a significant reduction in HRQL in the intervention arm. This may be attributed to the reduced heart failure class and heart function among the intervention participants (Hale et al., 2016). Overall, findings from the Hale et al. study demonstrate the potential benefits of implementing medication adherence, telehealth technologies. The systematic review by Inglis et al. (2015) identified the benefits of structured telephone support as well as non-invasive home telemonitoring in decreasing the risk of all-cause mortality and heart failure-related hospitalizations. These interventions were also found to help improve HRQL, knowledge about heart failure, and self-care behaviors among study participants

(Inglis et al., 2015). Koehler et al. (2018) found a significant reduction in the number of days lost due to unplanned hospitalizations as well as a decrease in all-cause mortality using a structured remote monitoring intervention. There were no improvements noted in HRQL using the telemonitoring intervention (Koehler et al., 2018). This could be related to major depression being part of the exclusion criteria (Koehler et al., 2018). In the Kotb et al. (2015) systematic review and meta-analysis, structured telephone support and telemonitoring decreased heart failure-related hospitalizations and risk of mortality compared to usual care. Additionally, ECG monitoring decreased heart failure hospitalizations (Kotb et al., 2015).

The Pedone et al. (2015) study evaluated the use of a telemonitoring system in patients 65 and older and found that this intervention resulted in decreased risk of all-cause mortality and hospitalization. In the systematic review and meta-analysis by Pekmezaris et al. (2018), findings included a significant reduction in heart failure-related mortality and all-cause mortality at 180 days when home telemonitoring was used. However, Pekmezaris et al. (2018) also noted that the study findings were time dependent and found that there were no significant reduction in odds at 365 days. Factors that may account for this include worsening of the disease and poor long-term patient adherence (Pekmezaris et al., 2018). There were no significant reductions in heart failure-related hospitalizations or all-cause hospitalizations observed in the study (Pekmezaris et al., 2018).

Kraai et al. (2015) found no significant reduction in heart failure admissions and all-cause mortality in the intervention group. The reason for this could be that the population included in the study sample was relatively healthy (Kraai et al., 2015).

Although no significant differences were noted in the IN TOUCH study, Kraai et al. (2015) mention there was a significant decrease in outpatient visits to the heart failure clinic. Additionally, there was a high rate of adherence to the telemonitoring intervention (Kraai et al., 2015). This suggests that telemonitoring may be a safe alternative to outpatient clinic visits and may help to improve accessibility to healthcare (Kraai et al., 2015). In the systematic review by Long et al. (2017) there were four studies that demonstrated a difference in readmission rates among heart failure patients; however, three of the studies lacked an adequate sample size to provide statistical significance. Ong et al. (2016) did not find a significant benefit from using health coaching, telephone calls and telemonitoring on readmissions or mortality. Although, there was significant improvement noted in HRQL at 180 days (Ong et al., 2016). However, Ong et al. (2016) state that further research is needed to validate these study findings.

Lastly, the systematic review and meta-analysis by Son et al. (2020) did not demonstrate a significant reduction in hospital readmissions using mobile phone-based interventions. However, hospital LOS was significantly reduced using the voice call intervention (Son et al., 2020). One study in the Son et al. (2020) systematic review and meta-analysis showed a statistically significant difference in disease prevention, lifestyle modifications, and disease management among the intervention group. There was no significant benefit noted with the other mobile phone-based interventions on reducing all-cause mortality, readmissions, ED visits, or improving HRQL (Son et al., 2020). However, Son et al. identified inconsistencies with the mobile phone-based interventions among the studies. Thus, pointing to the fact that variations in the intervention frequency, intensity, duration, and feedback provided attributed to these inconsistencies. Son et al.

also mention that the SMS interventions were one-way messages and not interactive. Additionally, the difficulties that some populations may have with these interventions, specifically among the elderly population, may have been an issue (Son et al., 2020).

Implications for Future Practice

The current literature was evaluated through this literature review and recommendations for future direction were made. A compilation of recommendations for clinical practice, future research, education, and policy follow.

Clinical Practice Recommendations

A wide variety of telemedicine interventions are available for use in the management of heart failure. Although the results of this literature review were mixed, telemedicine may be beneficial in improving health outcomes, such as reducing visits to the heart failure clinic, preventing readmissions, and decreasing days lost as a result of hospitalization and mortality (Hale et al., 2016; Inglis et al., 2015; Koehler et al., 2018; Kotb et al., 2015; Kraai et al., 2015; Pedone et al., 2015; Pekmezaris et al., 2018; Son et al., 2020). Additionally, telemedicine may help to increase access to healthcare services and improve the HRQL among heart failure patients (Inglis et al., 2015; Kraai et al., 2015; Long et al., 2017; Pekmezaris et al., 2018). Furthermore, telemedicine may improve heart failure knowledge and education as well as disease management and self-care behaviors among patients with heart failure (Inglis et al., 2015; Ong et al., 2016; Son et al., 2020). Given the current pandemic and more widespread use of telehealth technologies, advanced practice providers should be knowledgeable and adept at utilizing telehealth and telemedicine interventions. Additionally, providers should be skilled in

tailoring interventions to the specific population and age group they are serving while keeping patient preferences in mind.

Recommendations for Future Research

Future studies specific to the use of telehealth interventions in the heart failure patient population should focus on gaps and limitations identified in the literature. Small sample size was a commonly identified limitation (Hale et al., 2016; Pedone et al., 2015; Son et al., 2020). Subsequently, further studies merit a larger sample size to provide greater power to the study and to fully appreciate outcomes (Hale et al., 2016; Pedone et al., 2015). Additionally, Long et al. (2017) mentions a meta-analysis would be beneficial to evaluate and compare the design of telemonitoring modalities.

Kotb et al. (2015) point out that previous studies have only broadly assessed the effects of telemedicine in comparison to usual care and the available research comparing telemedicine interventions to each other is limited. Therefore, future studies should provide a comparison of the effectiveness of these various modalities (Inglis et al., 2015; Kotb et al., 2015). Kotb et al. (2015) also mention that a major focus of current research has been on telephone support and telemonitoring interventions. Newer telemedicine technologies, such as implantable devices, may be beneficial in improving patient engagement and adherence as well as providing more detailed health status information (Ong et al., 2016). Thus, it is pertinent that future studies be conducted utilizing the most current technologies as well as a broad range of modalities available in telemedicine such as video monitoring and ECG monitoring (Inglis et al., 2015; Kotb et al., 2015). Inglis et al. (2015) also discuss needing further research in utilizing closed-loop systems, which incorporates physiological measurements into decision-support tools.

Long et al. (2017) mentions the inconsistencies and lack of standardized design protocols among telemonitoring systems leading to poor intervention fidelity. Inglis et al. (2015) emphasizes the importance of developing a standardized design for future studies as well as reporting criteria. Areas for future research should also include testing all elements of interventions including duration (Pekmezaris et al., 2018). Additionally, studies should specify whether single interventions or multiple interventions are most effective (Son et al., 2020). Future studies should also focus on telemedicine and its effectiveness at specifically reducing 30-day readmissions (Long et al., 2017). Moreover, the long-term clinical significance of various telehealth interventions on heart failure outcomes should be addressed (Hale et al., 2016; Kotb et al., 2015).

Previous studies have extensively evaluated health outcomes; however, there is limited data on economic and societal outcomes including increasing access to care and reducing disparities among heart failure populations (Inglis et al., 2015; Pedone et al., 2015; Pekmezaris et al., 2018). A cost-analysis and comparison of various telemedicine interventions should also be an area of focus in future research (Inglis et al., 2015; Kotb et al., 2015; Pedone et al., 2015). Moreover, the full benefits of telemonitoring should be assessed including length and quality of life, reduced travel for patients and healthcare providers, and improved provider efficiency (Pekmezaris et al., 2018).

In the Hale et al. (2016) study, significant differences were noted among participants in regard to the NYHA classification of heart failure and HRQL. Thus, it is suggested that further studies obtain a larger sample size or utilize inclusion and exclusion criteria that would provide a narrower range of baseline characteristics (Hale et al., 2016; Pedone et al., 2015). In the Pedone et al. (2015) study, there were significant

physical impairments noted among the participants in the sample size; therefore, making generalizability difficult (Pedone et al., 2015). Moreover, a gap identified in the Long et al. (2017) study was the exclusion of individuals most likely at increased risk for 30-day readmissions, such as non-English speaking patients or patients with cognitive impairments. An area of focus for future studies should be on identifying specific subpopulations of heart failure patients that would most benefit from the telemedicine interventions (Kotb et al., 2015). Inglis et al. (2015) also identify the potential benefits of telemonitoring among heart failure patients during end-of-life. Furthermore, the target age of the participants in future studies should be considered as well as patient preferences (Inglis et al., 2015; Son et al., 2020).

Education Recommendations

There is an increasing need to identify methods effective at improving heart failure health outcomes and reducing the burden of heart failure on healthcare costs and utilization. As innovative telemedicine methods become more prevalent and widely used, healthcare providers need to be trained to competently utilize telehealth, telemonitoring, and telemedicine measures to care for various patient populations. Additionally, the identification of methods to disseminate research findings related to best practices in heart failure management is necessary.

Recommendations for Policy

Pekmezaris et al. (2018) state that regulation issues, problems with reimbursement, and other policy issues have hindered the widespread use of telemedicine in heart failure management. Pekmezaris et al. (2018) also mention that the recent changes in regulations that relaxed Medicare restrictions of telemedicine only address

videoconferencing reimbursements and do not address vital signs monitoring. Further loosening of restrictions pertaining to reimbursement for telehealth services as well as expansion of telehealth services should remain a priority (Pekmezaris et al., 2018).

Conclusion

The findings from this systematic literature review contribute to the current knowledge related to the impact of telemedicine in the heart failure population. Although the findings from this literature review provide mixed results, telemedicine modalities have the potential to improve outcomes among heart failure patients as well as reduce the burden on costs and healthcare utilization. Advanced practice providers can utilize the knowledge provided from this literature review to improve the care of heart failure patients. Furthermore, findings from this literature review have provided implications for clinical practice, research, education and policy.

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Appendix

Table A1*Database Search Description*

Database (or Search Engine)	Restrictions Added to Search	Dates Included in Database	General Subjects Covered by Database
1. PubMed	Full Text; Free Full Text; Abstract; Clinical Trial; Journal Article; Meta-Analysis; RCT; Review; Systematic Review; English Language; Peer Reviewed; Adult 19+ years	2015 through 2020	Provides access to articles related to medicine, nursing, dentistry, veterinary medicine, the health care system, and the preclinical sciences.
2. CINAHL Plus (with Full Text)	Full Text; English Language; Abstract; Academic Journals; Peer Reviewed; All Adult	2015 through 2020	Provides access to various nursing journals and materials within the realm of nursing and allied health.
3. Nursing and Allied Health Database (Formerly ProQuest Nursing and Allied Health Source)	Full Text; Peer Reviewed; Scholarly Journals; Include Studies; Include Heart Failure; Telemedicine; Document Type Article; English Language	2015 through 2020	Provides access to articles related to nursing and allied health.
4. Academic Search Premier (ASP)	Full Text; Scholarly & Peer Reviewed; Academic Journals; English Language	2015 through 2020	Provides access to over 4,600 articles in nearly every academic subject.
5. Cochrane Database of Systematic Reviews	Full Text	2015 through 2020	Provides access to Systematic Reviews related to healthcare and medicine.

Table A2*Data Abstraction Process*

Date of Search	Key Words	Results in PubMed	Results in CINAHL	Results in Nursing and Allied Health	Results in Academic Search Premier	Results in Cochrane Database of Systematic Reviews
11.14.20	Heart Failure AND TeleHealth	131	*13	182	*17	0
	Heart Failure AND TeleHealth OR TeleMonitoring OR TeleMedicine AND Readmission AND Mortality	*15 (3)	*34 (1)	282	45	*2 (1)
11.15.20	Heart Failure AND TeleHealth AND Readmission AND Mortality		*1	50		
	Heart Failure AND TeleMedicine AND Intervention AND Readmission AND Mortality AND Outcome			52		
	Heart Failure AND TeleMedicine AND Intervention AND Readmission AND 30 Day AND Mortality AND Outcome			*45 (6)		

***BOLD** = articles reviewed for match with systematic review inclusion criteria (parentheses indicate those articles meeting inclusion criteria)

Table A3*Characteristics of Literature Included and Excluded*

Reference	Included or Excluded	Rationale
Bauce, K., Fahs, D., Batten, J., & Whittemore, R. (2018). Videoconferencing for management of heart failure: An	Excluded	Integrative Review; Lower level of evidence

integrative review. <i>Journal of Gerontological Nursing</i> , 44(4), 45-52.		
Fors, A., Blanck, E., Ali, L., Ekberg-Jansson, A. Fu, M., Lindstrom Kjellberg, I., Makitalo, A., Swedberg, K., Taft, C., & Ekman, I. (2018). Effects of a person-centred telephone – support in patients with chronic obstructive pulmonary disease and/or chronic heart failure- A randomized controlled trial. <i>PLoS One</i> , 13(8), 1-12.	Excluded	Assessed outcome of telephone support in both COPD and heart failure patients
Hale, T. M., Jethwani, K., Kandola, M. S., Saldana, F., & Kvedar, J. C. (2016). A remote medication monitoring system for chronic heart failure patients to reduce readmissions: A two-arm randomized pilot study. <i>Journal of Medical Internet Research</i> , 18(4), 1-14.	Included	Randomized Pilot Study
Hofmann, R., Voller, H., Nagels, K., Bindl, D., Vettorazzi, E., Dittmar, R., Wohlgemuth, W., Neumann, T., Stork, S., Bruder, O., Wegscheider, K., Nagel, E., & Fleck, E. (2015). First outline and baseline data of a randomized, controlled multicenter trial to evaluate the health economic impact of home telemonitoring in chronic heart failure- CardioBeat. <i>Trials</i> , 16, 1-12.	Excluded	Study Design
Inglis, S. C., Clark, R. A., Dierckx, R., Prieto-Merino, D., & Cleland, J. G. (2015). Structured telephone support or non-invasive telemonitoring for patients with heart failure. <i>Cochrane Database of Systematic Reviews</i> , 10, 8-198.	Included	Systematic Review
Koehler, F., Koehler, K., Deckwart, O., Prescher, S., Wegscheider, K., Kirwan, B-A., Winkler, S., Vettorazzi, E., Bruch, C., Oeff, M., Zugck, C., Doerr, G., Naegele, H., Stork, S., Butter, C., Sechtem, U., Angermann, C., Gola, G., Prondzinsky, R., Edelmann, F., Spethman, S., Schellong, S. M., Schulze, P. C., Bauersachs, J., Wellge, B., Shoebel, C., Tajsic, M., Dreger, H., Anker, S. D., & Stangl, K. (2018). Efficacy of telemedical interventional management in patients with heart failure (TIM-HF2): A randomized controlled, parallel-group, unmasked trial. <i>The Lancet</i> , 392, 1047-1057.	Included	RCT
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. <i>PLoS One</i> , 10(2), 1-15.	Included	Systematic review and meta-analysis
Kraai, I., de Vries, A., Vermeulen, K., van Deursen, V., van der Wal, M., de Jong, R., Dijk, R., Jaarsma, T., Hillege, H., & Lesman, I. (2016). The value of telemonitoring and ICT-guided disease management in heart failure: Results from the IN TOUCH study. <i>International Journal of Medical Informatics</i> , 85(1), 53-60.	Included	RCT
Long, G., Babbitt, A., & Cohn, T. (2017). Impact of home telemonitoring on 30-Day hospital readmission rates for patients with heart failure: A systematic review. <i>MedSurg Nursing</i> , 26(5), 337-348.	Included	Systematic Review
Mehta, S. J., Volpp, K. G., Asch, D. A., Goldberg, L. R., Russell, L. B., Norton, L. A., Iannotte, L. G., & Troxel, A. B.	Excluded	Study protocol

(2019). Rationale and design of EMPOWER, a pragmatic randomized trial of automated hovering in patients with congestive heart failure. <i>Circulation: Cardiovascular Quality Outcomes</i> , 12(4), 1-15.		
Ong, M. K., Romano, P. S., Edgington, S., Aronow, H. U., Auerbach, A. D., Black, J. T., De Marco, T., Escarce, J. J., Evangelista, L. S., Hanna, B., Ganiats, T. G., Greenberg, B. H., Greenfield, S., Kaplan, S. H., Kimchi, A., Liu, H., Lombardo, D., Mangione, C. M., Sadeghi, B.,... Fonarow, G. C. (2016). Effectiveness of remote patient monitoring after discharge of hospital patients with heart failure: The better effectiveness after transition – Heart Failure (BEAT-HF) randomized clinical trial. <i>Journal of the American Medical Association Internal Medicine</i> , 176(3), 310-318.	Included	RCT
Pedone, C., Rossi, F. F., Cecere, A., Costanzo, L., & Incalzi, R. A. (2015). Efficacy of a physician-led multiparametric telemonitoring system in very old adults with heart failure. <i>Journal of the American Geriatrics Society</i> , 63, 1175-1180.	Included	Randomized trial
Pekmezaris, R., Torteza, L., Williams, M., Patel, V., Makaryus, A., Zeltser, R., Sinvani, L., Wolf-Klein, G., Lester, J., Sison, C., Lesser, M., & Kozikowski, A. (2018). Home telemonitoring in heart failure: A systematic review and meta-analysis. <i>Health Affairs</i> , 37(12), 1983-1989.	Included	Systematic Review and Meta-Analysis
Sohn, A., Speier, W., Lan, E., Aoki, K., Fonarow, G. C., Ong, M., & Arnold, A. W. (2020). Integrating remote monitoring into heart failure patients' care regimen: A pilot study. <i>PLoS One</i> , 15(11), 1-16.	Excluded	Pilot Study; Did not evaluate hospital readmissions or mortality
Son, Y-J., Lee, Y., & Lee, H-J. (2020). Effectiveness of mobile phone-based interventions for improving health outcomes in patients with chronic heart failure: A systematic review and meta-analysis. <i>International Journal of Environmental Research and Public Health</i> , 17(5), 1-13.	Included	Systematic Review and Meta-Analysis
Tajstra, M., Sokal, A., Gwozdz, A., Wilczek, M., Gacek, A., Wojciechowski, K., Gadula-Gacek, E., Adamowicz-Czoch, E., Chlostka-Niepieklo, K., Milewski, K., Rozentryt, P., Kalarus, Z., Gasior, M., & Pelonski, L. (2016). Remote supervision to decrease hospitalization rate. Unified and integrated platform for data collected from devices manufactured by different companies: Design and rationale of the RESULT study. <i>Annals of Noninvasive Electrocardiology</i> , 22, 1-7.	Excluded	Study Design
Uminski, K., Komenda, P., Whitlock, R., Ferguson, T., Nadurak, S., Hochheim, L., Tangri, N., & Rigatto, C. (2018). Effect of post-discharge virtual wards on improving outcomes in heart failure and non-heart failure populations: A systematic review and meta-analysis. <i>PLoS One</i> , 13(4), 1-16.	Included	Systematic Review and Meta-Analysis
Williams, C., & Wan, T. T. (2016). A remote monitoring program evaluation: A retrospective study. <i>Journal of Evaluation in Clinical Practice</i> , 22, 978-984.	Excluded	Retrospective study; Did not assess hospital readmissions or mortality
Yiadom, M. Y., Domenico, H., Byrne, D., Hasselblad, M. M.,	Excluded	Study protocol

<p>Gatto, C. L., Kripalani, S., Choma, N., Tucker, S., Wang, L., Bhatia, M. C., Morrison, J., Harrell, F. E., Hartert, T., & Bernard, G. (2018). Randomised controlled pragmatic clinical trial evaluating the effectiveness of a discharge follow-up phone call on 30-day hospital readmissions: Balancing pragmatic and explanatory design considerations. <i>British Medical Journal Open</i>, 8(2), 1-10.</p>		
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Table A4

Literature Review Table of All Studies Included

Citation	Study Purpose	Pop (N)/ Sample Size (n) /Setting(s)	Design/ Level of Evidence	Variables/ Instruments	Intervention	Findings	Implications
<p>Hale, T. M., Jethwani, K., Kandola, M. S., Saldana, F., & Kvedar, J. C. (2016). A remote medication monitoring system for chronic heart failure patients to reduce readmissions: A two-arm randomized pilot study. <i>Journal of Medical Internet Research</i>, 18(4), 1-14.</p>	<p>Evaluated the use of the MedSentry remote medication monitoring system compared to usual care in older adult patients with heart failure and who recently completed a heart failure telemonitoring program.</p>	<p>Older adult HF patients/ Sample size 25/ Outpatient setting</p>	<p>Randomized controlled pilot study/ LOE II</p>	<p>Questionnaires used to assess medication adherence, health status, and HRQoL. EMR was used to obtain data on heart function and unplanned hospitalizations and ED visits.</p>	<p>MedSentry remote medication monitoring system for 90 days (Remotely monitored electronic pillbox that sends an alert when a medication is due; Patient is contacted if medication is not taken)</p>	<p>The patients in the medication monitoring system group had an 80% reduced risk of all-cause hospitalization and a significant reduction in the number of all-cause hospitalization length of stay. Health related quality of life (HRQoL) was significantly reduced in the intervention arm, however, the intervention arm did have a poorer functioning at baseline.</p>	<p>The MedSentry medication monitoring system can be beneficial to use in patients with complex medication regimens or in combination with HF telemonitoring interventions.</p> <p>Use of the MedSentry medication monitoring system shows promising results in improving patient self-management, quality of patient care, reduce health care utilization and expenditure for patients with complex medication regimens.</p>
<p>Inglis, S. C., Clark, R. A., Dierckx, R., Prieto-Merino, D., & Cleland, J. G. (2015). Structured telephone support or non-invasive telemonitoring for patients with heart failure. <i>Cochrane Database of</i></p>	<p>To assess the effects of structured telephone support or non-invasive home telemonitoring in patients with heart failure.</p>	<p>Adults 18+ and recently discharged from acute care setting/ Sample size ranged from 34 to 1,653/ Outpatient</p>	<p>Systematic Review/ LOE I</p>	<p>Usual care, structured telephone support, telemonitoring devices</p>	<p>Use of structured telephone support or non-invasive home telemonitoring</p>	<p>41 studies were included in this Systematic Review. The use of non-invasive telemonitoring and structured telephone support resulted in reduced all-cause mortality and heart failure-related hospitalizations. No reduction seen in the risk of all-</p>	<p>The use of non-invasive telemonitoring and structured telephone support reduces the risk of all-cause mortality and heart failure-related readmissions.</p>

Citation	Study Purpose	Pop (N)/ Sample Size (n) /Setting(s)	Design/ Level of Evidence	Variables/ Instruments	Intervention	Findings	Implications
<i>Systematic Reviews, 10, 8-198.</i>						cause hospitalizations. 1 study resulted in reduced length of stay.	
Koehler, F., Koehler, K., Deckwart, O., Prescher, S., Wegscheider, K., Kirwan, B-A., Winkler, S., Vettorazzi, E., Bruch, C., Oeff, M., Zugck, C., Doerr, G., Naegele, H., Stork, S., Butter, C., Sechtem, U., Angermann, C., Gola, G., Prondzinsky, R., Edelmann, F., Spethman, S., Schellong, S. M., Schulze, P. C., Bauersachs, J., Wellge, B., Shoebel, C., Tajsic, M., Dreger, H., Anker, S. D., & Stangl, K. (2018). Efficacy of telemedical interventional management in patients with heart failure (TIM-HF2): A randomized controlled, parallel-group, unmasked trial. <i>The Lancet, 392, 1047-1057.</i>	To assess the efficacy of a remote patient intervention on mortality and morbidity in heart failure patients.	Hospitalized patients and patients from cardiology and general practitioner practices/ n=1571/ Germany	Prospective, randomized, controlled, parallel-group, unmasked multicentre trial/ LOE II	Telemonitoring system, Self-rated health status scale, Living with Heart Failure Questionnaire	Remote patient management intervention that included a daily weight, blood pressure, heart rate, heart rhythm, SpO2, and self-rated health status	Fewer days lost related to unplanned hospitalizations and all-cause mortality in the intervention group. Number of days lost in the usual care group was 24 days. Number of days lost in the intervention group was 18 days. All-cause mortality is reduced using remote patient management.	Increased risk of readmission with remote patient management, however, LOS may be shorter. The use of a remote patient management intervention could aid in lowering the percentage of days lost due to hospital admissions and all-cause mortality.
Kotb, A., Cameron, C., Hsieh, S., & Wells, G. (2015). Comparative effectiveness of	To determine the impact of telemedicine options in heart failure patients.	Mean age 65/ n=10,193	Systematic Review and Meta-Analysis/ LOE I	Usual care, telemonitoring interventions, ECG transmission	Telephone support, telemonitoring, video monitoring, or electrocardiographic monitoring	A total of 30 RCTs were included. Telephone support resulted in a reduced odds of mortality and hospitalizations.	The use of structured telephone support and telemonitoring results in a significantly reduced odds of death and heart

Citation	Study Purpose	Pop (N)/ Sample Size (n) /Setting(s)	Design/ Level of Evidence	Variables/ Instruments	Intervention	Findings	Implications
different forms of telemedicine for individuals with heart failure (HF): A systematic review and network meta-analysis. <i>PLoS One</i> , 10(2), 1-15.						Telemonitoring resulted in reduced odds of mortality and reduced hospitalizations. ECG monitoring resulted in reduced odds of hospitalizations.	failure related hospitalization. Telephone support and telemonitoring interventions may be beneficial for rehabilitating patients with heart failure.
Kraai, I., de Vries, A., Vermeulen, K., van Deursen, V., van der Wal, M., de Jong, R., Dijk, R., Jaarsma, T., Hillege, H., & Lesman, I. (2016). The value of telemonitoring and ICT-guided disease management in heart failure: Results from the IN TOUCH study. <i>International Journal of Medical Informatics</i> , 85(1), 53-60.	To assess whether telemonitoring aids in reduction of heart failure hospitalizations and mortality and if the addition of an information and computing technology guided disease management system (ICD-guided-DMS) results in improved outcomes or lowers healthcare costs.	Adults 18+/Sample size n=177/ Admission to intensive care/corona ry care unit or cardiology ward or outpatient HF clinic	RCT/ LOE II	Questionnaires	ICT-guided-DMS group and telemonitoring group	There was no benefit found in all-cause mortality, HF-readmission, and change in HR-QoL with the use of telemonitoring in addition to ICT-guided-DMS with CDSS.	A telemonitoring intervention can be a safe and effective option especially in rural or understaffed areas and can help reduce HF-related clinic visits.
Long, G., Babbitt, A., & Cohn, T. (2017). Impact of home telemonitoring on 30-Day hospital readmission rates for patients with heart failure: A systematic review. <i>MedSurg Nursing</i> , 26(5), 337-348.	To assess the effectiveness of home telemonitoring on 30-day readmissions in HF patients	Adults 50+/ Sample size ranged from 70-48,538/ Eastern United States in health systems or home healthcare agency	Systematic Review/ LOE I	Usual post-discharge care/ Equipment that collected patient data, phone surveys	Home telemonitoring intervention	Reviewed 6 studies. No significant difference in readmission rates. 50% decrease in mortality with the use of home telemonitoring.	One study showed a 50% decrease in mortality with the use of home telemonitoring. Many of the studies lacked an adequate sample size.
Ong, M. K., Romano, P. S., Edgington, S., Aronow, H. U., Auerbach, A. D., Black, J. T., De Marco, T.,	To determine whether telemonitoring approaches are beneficial for heart failure patients following hospitalization	Hospitalized individuals 50 years and older/ n-1437/ 6 academic medical centers in	RCT/ LOE II	Electronic equipment that recorded BP, HR, symptoms, and weight.	A combination of health coaching telephone calls and telemonitoring were used.	Primary outcome assessed all-cause readmission within 180 days from hospital discharge. Secondary outcomes assessed all-cause readmissions	Novel remote monitoring approaches including implantable devices could increase patient adherence or provide improved

Citation	Study Purpose	Pop (N)/ Sample Size (n) /Setting(s)	Design/ Level of Evidence	Variables/ Instruments	Intervention	Findings	Implications
Escarce, J. J., Evangelista, L. S., Hanna, B., Ganiats, T. G., Greenberg, B. H., Greenfield, S., Kaplan, S. H., Kimchi, A., Liu, H., Lombardo, D., Mangione, C. M., Sadeghi, B.,... Fonarow, G. C. (2016). Effectiveness of remote patient monitoring after discharge of hospital patients with heart failure: The better effectiveness after transition – Heart Failure (BEAT-HF) randomized clinical trial. <i>Journal of the American Medical Association Internal Medicine</i> , 176(3), 310-318.		California				within 30 days, all-cause mortality at 30 and 180 days, and QoL at 30 and 180 days. Health coaching telephone calls plus telemonitoring showed no significant reduction in 180 day all-cause mortality after hospital discharge, 30 day readmissions, or 180 day mortality rates.	information after hospital discharge. Use of health coaching and telemonitoring may lead to improved quality of life at 180 days.
Pedone, C., Rossi, F. F., Cecere, A., Costanzo, L., & Incalzi, R. A. (2015). Efficacy of a physician-led multiparametric telemonitoring system in very old adults with heart failure. <i>Journal of the American Geriatrics Society</i> , 63, 1175-1180.	To assess the effectiveness of telemonitoring vital signs and use of telephone support on 6 month survival and hospital admissions in elderly patients with heart failure.	Elderly patients age 65 and older with heart failure/ Sample size n=90/ geriatric acute care ward and outpatient clinic in Rome, Italy	Randomized trial/ LOE II	Standard care versus Telemonitoring system that monitors oxygen saturation, heart rate, and blood pressure; ADLs and NYHA class were rated using scales, Cumulative Illness Rating Scale, serum level of NT-proBNP	Telemonitoring system and Telephone support provided by a geriatrician	Incidence of the main outcome was 42% in the control group and 21% in the intervention group.	Use of a physician led telemonitoring and telephone support lowers risk of all –cause mortality and hospitalization in elderly patients with HF.
Pekmezaris, R., Torteza, L., Williams, M., Patel, V., Makaryus, A.,	To assess the effectiveness of home telemonitoring in heart failure patients to lower mortality	Adults 18+/ Sample size n=4,923	Systematic Review and Meta-Analysis/ LOE I	Telemonitoring and transmission	Home telemonitoring that used vital sign monitoring and transmission	26 RCTs were used to assess the effectiveness of home telemonitoring. Home telemonitoring	There is a significant reduction in heart failure related and all-cause mortality with the use of home

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Zeltser, R., Sinvani, L., Wolf-Klein, G., Lester, J., Sison, C., Lesser, M., & Kozikowski, A. (2018). Home telemonitoring in heart failure: A systematic review and meta-analysis. <i>Health Affairs</i> , 37(12), 1983-1989.	and hospital utilization.					resulted in a decreased odds of all-cause mortality and heart failure related mortality at 180 days but not at 365 days. A significant increased odds of all-cause emergency department visits were seen with home telemonitoring at 180 days. There was no significant impact on all-cause hospitalization at 90 or 180 days or heart failure related hospitalization at 180 days.	telemonitoring.
Son, Y-J., Lee, Y., & Lee, H-J. (2020). Effectiveness of mobile phone-based interventions for improving health outcomes in patients with chronic heart failure: A systematic review and meta-analysis. <i>International Journal of Environmental Research and Public Health</i> , 17(5), 1749-	To identify the most effective phone-based interventions for heart failure patients	Adults 18+/ n=2,534/ NA	Systematic Review and Meta-Analysis/ LOE I	Hospitalization, readmission, hospital days, costs, ED visits, survival, NHA class, LOS, QoL, self-care behaviors, mortality, BNP, LVEF, ED visits, all-cause mortality, medication adherence	Voice call intervention, telemonitoring, and short message services	8 RCTs were analyzed. Primary outcomes looked at all-cause mortality, readmission, emergency department visits, hospital LOS, and quality of life. Secondary outcomes include self-care behaviors and other clinical outcomes. Voice call interventions had a significant effect on hospital length of stays. There were no significant impacts on all-cause mortality, readmission, emergency department visits, or quality of life.	Voice call interventions are effective at reducing hospital length of stays in HF patients. Future studies needed to determine the most effective mobile phone-based intervention to improve health outcomes.
Uminski, K., Komenda, P., Whitlock, R., Ferguson, T., Nadurak, S., Hochheim, L., Tangri, N., & Rigatto, C. (2018). Effect of post-discharge	To assess the effectiveness of post-discharge virtual wards on hospital readmissions and mortality in heart failure patients.	Adults 18+/ n=4,820/ NA	Systematic Review and Meta-Analysis/ LOE I	Usual care, telemonitoring	Post discharge virtual wards via telephone or telemonitoring	6 RCTs were related to heart failure patients exclusively. Post discharge virtual wards resulted in a reduced risk of mortality. Additionally, heart failure related readmissions were reduced. All-cause readmissions were	Post discharge virtual wards appear to be beneficial in reducing all-cause mortality and heart failure related hospital admissions.

Citation	Study Purpose	Pop (N)/ Sample Size (n) /Setting(s)	Design/ Level of Evidence	Variables/ Instruments	Intervention	Findings	Implications
virtual wards on improving outcomes in heart failure and non-heart failure populations: A systematic review and meta-analysis. <i>PLoS One</i> , 13(4), 1-16.						not reduced.	