

Telehealth Impact on Patient Outcome in Heart Failure Patients: A Narrative Synthesis Review

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Abstract

Background: Studies have reported significant benefit in the health outcomes in heart failure patients due to Telehealth intervention, yet the actual extent of their impact remains unclear due to varying results across different studies. The review aims to summarize the existing evidence on the impact of Telehealth on patient outcome in HF patients. **Method:** PubMed, MEDLINE, CINAHL, and Embase databases were searched for studies published between 2013 to 2024, focusing on Telehealth intervention to remotely monitor and manage heart failure patients, with the following endpoints: All cause, Heart failure and cardiovascular disease-related readmission, mortality and hospitalizations, Emergency Department visits, changes in self-care behaviour and quality of life. Identified articles were screened for relevance based on eligibility criteria. Included were studies published in English language, original articles and reviews. Due to heterogeneity among the studies a narrative synthesis approach was used to synthesize and interpret findings from multiple studies. **Results:** This review includes 54 articles (26 original articles and 28 reviews). Largely studies were conducted in Europe (33%). Telemonitoring with telephone support was the most common mode for posthospitalization follow-ups, where the patients monitored their vital signs and reported their health behaviours and symptoms. There is mixed evidence with regards to the impact of Telehealth on health outcomes in heart failure patients. However, majority of the studies have demonstrated considerable improvement in the heart failure knowledge, self-care behaviour and health-related quality of life, as well as reductions in mortality, hospitalizations, and length of hospital stays due to Telehealth intervention. There is also lack of evidence on how long the effectiveness lasts, with

studies showing improvement for the short term, the effect did not sustain for a longer time after the intervention was discontinued. To better understand the impact of the Telehealth on patient's outcome, it is recommended that the future studies evaluate long-term adherence and efficiency of Telehealth post intervention with follow-up for an extensive period. **Conclusion:** Despite the potential of Telehealth interventions in improving patient outcomes, its effectiveness can vary based on the type of intervention used, patient population and study design, which highlights the need for optimization of Telehealth programs.

Keywords

Telehealth, Heart Failure, Patient Outcome

1. Background

Heart failure (HF) is considered one of the most significant challenges in modern medicine and imposes a substantial economic burden on society due to the complexities involved in treating HF patients and the long-term management required for those living with HF (Planinc et al., 2020). Effective management of heart disease, both during hospitalization and after discharge is crucial as patients discharged after an episode of acute HF have an increased risk of hospitalizations and deaths within the subsequent 3 months (Rosano et al., 2022). A recent systematic review conducted to summarise 30-day and 1-year all-cause readmission and mortality rates for patients with HF globally reported that of the 1.5 million individuals hospitalized for HF, 13.2% were readmitted within 30 days and 35.7% within 1 year, 7.6% died within 30 days and 23.3% within 1 year (Foroutan et al., 2023). The transition of care from the hospital creates a vulnerable period for patients and caregivers, often leading to worsening of symptoms, non-compliance with medications and diet regimens, and increased readmissions and emergency department visits (Van Spall et al., 2017; Elsener et al., 2023). Regular and frequent follow-ups with these patients have been shown to reduce mortality and hospitalizations due to acute exacerbations of HF (Rebolledo Del Toro et al., 2023). The utilization of technology, including mobile applications, wearable devices, telemedicine platforms, and remote monitoring systems, has revolutionized the landscape of healthcare delivery, particularly in the management of chronic conditions like HF (Farias et al., 2020; Liu et al., 2022; Ding et al., 2023; Scholte et al., 2023; Masotta et al., 2024).

Telehealth interventions encompass a blend of monitoring vital signs, notably weight, to promptly identify fluid retention, along with symptom reporting using concise, automated daily surveys (Rebolledo Del Toro et al., 2023; Scholte et al., 2023; Choi, 2025). Mainly the results from recent systematic reviews and meta-analysis, evaluating the impact of Telehealth intervention on HF patients recently discharged from hospitals as well as those from the broader community, have in-

indicated significant improvement in the health-related quality of life (QoL) (Zhu et al., 2020; Lee et al., 2022; Morken et al., 2022; Liu et al., 2022; Ding et al., 2023; Stergiopoulos et al., 2024), patient HF knowledge (Ruiz-Pérez et al., 2019; Liu et al., 2022), self-efficacy and self-care behaviours (Ruiz-Pérez et al., 2019; Nick et al., 2021; Liu et al., 2022; Lee et al., 2022; Ding et al., 2023), decreased likelihood of hospitalization (Zhu et al., 2020; Mhanna et al., 2022; Fatrin et al., 2022; Ding et al., 2023; Scholte et al., 2023; Rebolledo Del Toro et al., 2023; Garanin et al., 2024; Wang et al., 2024) and emergency department (ED) visits (Graves et al., 2013), shorter hospital stays (Xiang et al., 2013; Tan et al., 2024), reduction in mortality rates (Ruiz-Pérez et al., 2019; Zhu et al., 2020; Liu et al., 2022; Fatrin et al., 2022; Stergiopoulos et al., 2024), healthcare utilization, and care expense (Vestergaard et al., 2020). In general, evidence indicates that virtual interventions hold promise for enhancing health outcomes in patients with HF, though the actual extent of their impact remains uncertain due to varying results across different studies.

In this study, we aim to summarize the existing evidence (including trials, observational studies, meta-analyses and systematic reviews) assessing impact of Telehealth on patient outcome in HF patients and further identify gaps and potential future research directions.

2. Methodology

The review was conducted utilizing following steps: 1) Framing research questions; 2) Defining inclusion and exclusion criteria; 3) Developing search strategy; 4) Screening studies based on pre-defined criteria; 5) Extracting data from included studies; 6) Collating, Summarizing, and Reporting the Results.

2.1. Research Question

How does the use of Telehealth impact patient outcome in HF patients?

Population: HF patients aged > 18 year; Intervention: Telehealth; Comparator: Usual or standard care; Outcomes: Reduction in mortality, hospitalizations and readmission rate, ED visits, length of stay, changes in self-care behaviour and QoL.

2.2. Inclusion and Exclusion Criteria

Included were studies: 1) In English language, 2) Published between 2013 and 2024, 3) Original peer-reviewed full text articles, add reviews, systematic reviews, meta analysis. We excluded case series, case study, protocols, abstracts, meeting summaries, theses, letters, editorials, opinions, and conference papers.

2.3. Search Strategy

A specific search strategy was generated using medical subject headings (MeSH) and free texts for each database. A thorough literature search was conducted on PubMed, MEDLINE, CINAHL, and Embase databases, focusing on studies pub-

lished between 2013 to 2024, utilizing Telehealth to remotely monitor and manage HF patients. The search included combinations of keywords related to HF and Telehealth such as “Heart Failure”, “Cardiovascular disease”, “virtual care”, “tele-monitoring”, “telemedicine”, “Teleconsultation”, “mHealth”, “Telehealth”, “e-Health systems”, “remote monitoring” employing Boolean operators (“AND” and “OR”) for each term. We included the studies with the following endpoints: HF-related mortality, HF-related hospitalizations, HF related readmission, cardiovascular (CV) disease-related readmission, mortality and hospitalizations, ED visits, changes in self-care behaviour and QoL.

2.4. Screening Studies Based on Pre-Defined Criteria

The screening was conducted using Covidence software, which is an online software tool designed to streamline the process of conducting a systematic review. The Articles were imported into Covidence software. During the initial screening phase, all reviewers independently screened articles against the eligibility criteria based on the title and abstract. Full text articles were obtained for all the eligible studies, and independently assessed by the reviewers against the inclusion and exclusion criteria. Two authors independently reviewed full text articles. Any discrepancies were resolved through discussion or consultation with all the authors.

2.5. Extracting Data from Included Studies

A standard data extraction form was developed and used to collect data from each included study. The articles were equally divided among all authors, making sure that each article was reviewed by at least two authors. All the authors extracted information independently, any discrepancies were resolved through discussion and in consultation with other reviewers.

Following information was extracted on a spreadsheet: Publication year, country, study design, study population, sample size, follow up/Intervention duration, endpoints/primary or secondary outcome (mortality, hospitalizations, readmission, ED visits, changes in self-care behaviour and QoL), Intervention/Technology used, results, and conclusion. (Supplementary file: The supplementary data table is too large to include here. Please contact the corresponding author via email to obtain the file directly).

2.6. Collating, Summarizing, and Reporting the Results

A narrative synthesis was conducted, the reported outcomes and findings were synthesized and grouped into specific themes identified by the authors (Popay et al., 2006). We could not perform a systematic review and/or meta analysis due to high heterogeneity in the existing evidence in relation to type of intervention used for HF management, follow up duration, use of different measurement tools/scales to assess impact and disparity in the outcome of interest, hence a narrative synthesis approach was used to provide a comprehensive overview of the findings.

3. Results

The PRISMA diagram illustrates the study selection process (**Figure 1**). 329 studies were imported in Covidence for screening. After removal of duplicates, 310 studies were screened based on titles and abstracts. 74 articles underwent full text review and 54 studies met the inclusion criteria. This review reports 54 studies that focuses on adult F patients utilizing Telehealth to monitor and manage their condition remotely post discharge from hospital and exploring its impact on the patient outcome such as mortality, hospitalizations, readmission, ED visits, length of stay, changes in self-care behaviour and QoL.

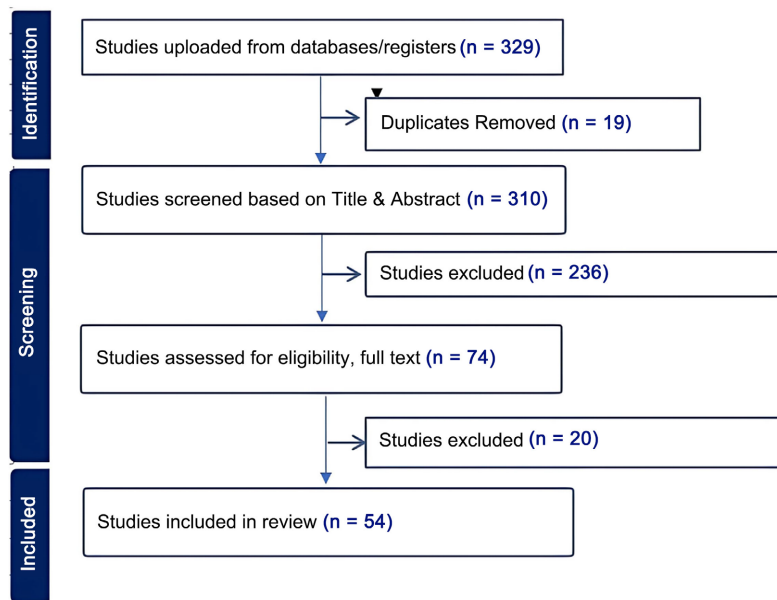


Figure 1. PRISMA diagram.

3.1. Study Characteristics

Among the included 54 studies, 33.3% ($n = 18$) studies were published before 2020 [2013—4, 2015—3, 2016—1, 2017—2, 2018—3, 2019—6] and approximately 66.7% ($n = 36$) between 2020 to 2024 [2020—6, 2021—6, 2022—13, 2023—5, 2024—5]. Most studies were conducted in Europe—18, North America—16 and Asia—10 followed by Middle east—3, South America—3, UK—3 and Australia—1.

We included 14 RCT, 11 observational studies and 1 quasi-experimental study with a pretest-post-test design and repeated measures. Systematic review and meta-analysis—18, Systematic review—8, integrative research review—1, Scoping Review—1. Systematic reviews and meta-analysis mainly included randomised controlled trials and observational studies, comparing Telehealth intervention group with the control group (receiving usual care or standard care as part of routine clinical practice).

3.2. Sample Size & Population

There was a wide variation in the sample size, in the observational and experi-

mental studies ranging from minimum of 30 to a maximum of 26,128 participants.

The studies comprised of both male and female patients diagnosed with HF and expected to be discharged to their home. Most of the studies focused on patients aged 18 years or older, while some studies involved patients aged ≥ 45 years (Dorsch et al., 2021; Fatrin et al., 2022) ≥ 50 years (Ong et al., 2016; Fors et al., 2018) or patients aged 65 and older (Pedone et al., 2015; Tsai et al., 2022; Chan et al., 2022), specifically after hospital admission or disease progression. Primarily the studies encompassed patients who were in New York Heart Association functional class II or III, hospitalised for HF within 12 months before randomisation, and had a left ventricular ejection fraction (LVEF) of either less than 45% or more than 45%. Studies included both English-speaking and non-English-speaking participants, and rural populations were part of the study cohorts (Graves et al., 2013; Ruiz-Pérez et al., 2019).

3.3. Follow Up Duration

The follow up duration ranged from 10 days to a maximum of 60 months (5 years). Mostly ($n = 20$) studies conducted one time measurement of the outcome variables (Pedone et al., 2015; Ong et al., 2016; Martín-Lesende et al., 2017; Koehler et al., 2018; Wagenaar et al., 2019; Negarandeh et al., 2019; Gingele et al., 2019; Park et al., 2019; Baecker et al., 2020; Maor et al., 2020; Ware et al., 2020; Yanicelli et al., 2021; Ho et al., 2021; Poelzl et al., 2022; Indraratna et al., 2022; Galinier et al., 2022; Tsai et al., 2022; Naik et al., 2022; Völler et al., 2022; Knoll et al., 2023). Some studies ($n = 4$) measured outcome variables at different time intervals such as at baseline and at 1, 3, 6 months or further, to see changes while the intervention was provided (Smeets et al., 2017; Dorsch et al., 2021; Son et al., 2023). Two studies ($n = 2$) provided intervention for certain duration and then stopped the intervention and followed up for an extended period to measure various outcomes such as QoL, self-efficacy, self-care, mortality and incidence of rehospitalization (Mizukawa et al., 2019; Koehler et al., 2020).

3.4. Telehealth

The reviewed articles assessed specific virtual technologies, targeting patients with HF. The most common mode for posthospitalization follow-up was telemonitoring (smart phone application based) with telephone support, where the patients monitored their vital signs and reported their health behaviours and symptoms. One of the included studies investigated the potential use of vocal biomarkers with adverse outcome among patients with HF, the findings from the study supports the use of voice signal analysis as a non-invasive diagnostic biomarker for identifying high-risk HF patients (Maor et al., 2020). Additionally, a study utilized bioimpedance device, which collected disease related data from the Cardiovascular Implantable Electronic devices and transmitted to an online database accessible to the multidisciplinary HF team for managing chronic conditions (Smeets et al.,

2017).

Telehealth Interventions included both non-invasive [Structured telephone support (STS), Telemonitoring (individual), Telemonitoring in combination with telephone support) and invasive [Cardiac implantable electronic devices, Invasive haemodynamic monitoring] devices.

1) Structured telephone support—Patient receives call from healthcare provider at scheduled intervals to provide support and education (call usually focused on assessing common HF symptoms; medication management, diet, education on signs and symptoms of an exacerbation and self-care strategies; and connecting patients to HF clinicians as needed).

2) Telemonitoring via mobile or tablet applications, interactive mobile text message, videoconferencing or wearables such as patches and watches—Patients vitals such as bodyweight, blood pressure, heart rate and other health related data were collected through an ambulatory remote monitoring system and sent to monitoring team and reviewed by clinician; readings outside thresholds are flagged, monitoring team follows up with patients on all concerning flags and alerts

3) Telemonitoring in combination with telephone support

4) Invasive/Implantable remote monitoring systems—Patients health related data from the devices implanted or inserted into the body are transmitted to an online database accessible to the monitoring team.

Participants in the Intervention group received Intervention in addition to the usual care, whereas the participants in the control group received usual care alone (Pedone et al., 2015; Ong et al., 2016; Fors et al., 2018; Koehler et al., 2018; Wagenaar et al., 2019; Negarandeh et al., 2019; Gingele et al., 2019; Koehler et al., 2020; Yanicelli et al., 2021; Dorsch et al., 2021; Poelzl et al., 2022; Indraratna et al., 2022; Tsai et al., 2022; Naik et al., 2022; Völler et al., 2022; Knoll et al., 2023; Son et al., 2023).

3.5. HF Self-Management Education

The most common intervention to systematically manage HF were based on the provision of patient education (Wakefield et al., 2013; Ruiz-Pérez et al., 2019). HF self-management education was provided by the health care professionals, pre-discharge from the hospital or post discharge to home via telephone (regularly scheduled telephone coaching) or mHealth (mobile health)-delivered education for use on smartphones and tablets and other mobile devices by means of apps, website, SMS messages and social media-delivered education programmes with information targeted at patients and their family/carers to improve self-care.

3.6. Impact of Telehealth on Patient Outcome

3.6.1. Effect of Telehealth on Self-Care Behaviour and QoL

Most common tools used to measure self-care behaviour and QoL in individuals with HF were—Self-Care of Heart Failure Index (SCHFI) and European Heart Failure Self-care Behavior Scale (EHFScBS) to assess how patients are managing their condition through various self-care activities. Minnesota Living with Heart

Failure Questionnaire (MLHFQ) and EuroQol 5-Dimension 5-level (EQ-5D-5L) questionnaire for assessing self-reported QoL.

Evidence from Original articles

Several studies have demonstrated significant improvement in the self-care behaviour (Wagenaar et al., 2019; Negarandeh et al., 2019; Mizukawa et al., 2019; Ware et al., 2020; Yanicelli et al., 2021; Poelzl et al., 2022; Son et al., 2023) of the individual receiving Telehealth (Intervention group) compared to the usual or standard care group. In contrast a study by Dorsch et al., the Telehealth intervention did not impact the self-care behaviour (SCHFI score) of HF patients (Dorsch et al., 2021). One of the randomized controlled trials utilizing two interventions [website and interactive platform for HF disease management (the e-Vita platform) with telemonitoring facilities] showed improvement in the self-care behaviour in HF patients on the short term, but not on the long term. After 3 months of follow-up, the mean score on the self-care scale was significantly higher in the intervention group compared to usual care. These effects decreased during the following 9 months, and no clear differences were seen at 12 months between the groups (Wagenaar et al., 2019).

QoL score in the patient's receiving Telehealth was significantly improved compared with the usual care (Ong et al., 2016; Wagenaar et al., 2019; Mizukawa et al., 2019; Ware et al., 2020; Ho et al., 2021; Indraratna et al., 2022; Völler et al., 2022). In one of the study, significant improvement in health-related QoL was observed at 6 weeks in the intervention group ($P = 0.04$) however the intervention did not sustain its effects at 12 weeks ($P = 0.78$) (Dorsch et al., 2021). On the contrary, some studies reported no improvement in the QoL in the intervention group (Koehler et al., 2018; Wagenaar et al., 2019). In a randomised controlled trial conducted by Gingele et al., tailored telemonitoring stabilised the functional status of HF patients but did not improve QoL post intervention (Gingele et al., 2019).

Evidence from Reviews

A significant number of studies conducting add reviews, systematic review and meta-analysis have shown improvement in the health-related QoL (Wakefield et al., 2013; Pandor et al., 2013; Graves et al., 2013; Inglis et al., 2015; Zhu et al., 2020; Lee et al., 2022; Liu et al., 2022; Morken et al., 2022; Ding et al., 2023; Stergiopoulos et al., 2024), patient HF knowledge (Graves et al., 2013; Inglis et al., 2015; Ruiz-Pérez et al., 2019; Liu et al., 2022) and self-care behaviours (Graves et al., 2013; Inglis et al., 2015; Ruiz-Pérez et al., 2019; Nick et al., 2021; Liu et al., 2022; Lee et al., 2022; Ding et al., 2023). On the other hand, some studies reported no differences in health-related QoL scores ($P = 0.24$) between the intervention and the usual or standard care group (Wang et al., 2024). A Cochrane review on use of mHealth-delivered education programmes for people with HF showed no evidence of a difference in HF knowledge ($P = 0.51$, 3 studies, 411 participants) uncertainty in the evidence for health-related QoL ($P = 0.93$, 4 studies, 942 participants) and self-efficacy at baseline ($P = 0.31$; 1 study, 29 participants) compared to usual care (Allida et al., 2020).

The impact on QoL was variable between studies, with different scores and reporting measures used. In a systematic review of randomized clinical trials conducted by Rebolledo Del Toro et al., no improvement in QoL was observed in studies using MLHQ or EQ-5D, whereas studies applying SF-36 and KCCQ reported statistically significant improvement (Rebolledo Del Toro et al., 2023).

3.6.2. Effect of Telehealth on Clinical Outcomes (Hospitalization, Readmission, Mortality and Length of Stay)

There is mixed evidence with regards to impact of Telehealth on hospitalization, readmission, mortality and length of stay of HF patients.

Evidence from Original articles

A significant reduction in the number of hospitalizations [all-cause (Pedone et al., 2015; Martín-Lesende et al., 2017; Ware et al., 2020; Knoll et al., 2023), CV (Pedone et al., 2015) or HF-related (Pedone et al., 2015; Martín-Lesende et al., 2017; Ware et al., 2020; Naik et al., 2022; Knoll et al., 2023)], rehospitalization [all-cause (Indraratna et al., 2022), CV (Indraratna et al., 2022) or HF related (Fors et al., 2018; Mizukawa et al., 2019; Yanicelli et al., 2021; Ho et al., 2021; Tsai et al., 2022; Poelzl et al., 2022)] and emergency department attendances (Martín-Lesende et al., 2017; Ho et al., 2021; Indraratna et al., 2022) was observed in the Telehealth group compared to usual care group. With some studies showing no significant difference in the hospitalization (Smeets et al., 2017; Wagenaar et al., 2019) or readmission (Negarandeh et al., 2019; Baecker et al., 2020; Dorsch et al., 2021) related to HF and hospitalisation (Koehler et al., 2018) or readmission (Ong et al., 2016; Park et al., 2019) for any cause.

Majority of the studies showed no significant differences in all-cause mortality (Ong et al., 2016; Koehler et al., 2018; Wagenaar et al., 2019; Völler et al., 2022) and CV mortality (Koehler et al., 2018; Indraratna et al., 2022) between the intervention and usual care groups. Only few studies showed significant reduction in the composite of all-cause (Pedone et al., 2015; Allida et al., 2020; Poelzl et al., 2022; Naik et al., 2022; Knoll et al., 2023) and HF related (Pedone et al., 2015; Fors et al., 2018; Naik et al., 2022) mortality between the groups.

Reduction in length of stay was observed post monitoring in few studies (Martín-Lesende et al., 2017; Ho et al., 2021).

Evidence from Reviews

Results from add reviews, systematic reviews and meta-analysis shows effectiveness of Telehealth in decreasing all-cause (Zhu et al., 2020; Liu et al., 2022; Ding et al., 2023; Wang et al., 2024; Masotta et al., 2024), CV (Zhu et al., 2020; Kuan et al., 2022) and HF-related hospitalization (Xiang et al., 2013; Pandor et al., 2013; Inglis et al., 2015; Kotb et al., 2015; Zhu et al., 2020; Mhanna et al., 2022; Fatrin et al., 2022; Rebolledo Del Toro et al., 2023; Ding et al., 2023; Scholte et al., 2023; Garanin et al., 2024; Wang et al., 2024), readmission (Wakefield et al., 2013; Graves et al., 2013; Chan et al., 2022; Ramtin et al., 2023; Masotta et al., 2024), ED (Graves et al., 2013) and clinic/physician visits (Wakefield et al., 2013) compared with usual care strategies. On the contrary, some studies showed no/neutral effect

of telemonitoring on all-cause hospitalization or readmissions of patients with HF (Drews et al., 2021; Kuan et al., 2022; Lee et al., 2022; Stergiopoulos et al., 2024; Garanin et al., 2024) as opposed to standard care. In one of the recent metaanalysis, remote physiological monitoring of HF patients showed no improvement in the rates of HF-related hospitalization (RR: 0.94; $P = 0.36$) and ED visits (RR 0.80, $P = 0.14$) compared to the standard care group. However, a tendency toward improved survival in HF patients managed with RPM guided strategies was observed (Mhanna et al., 2022).

Some studies showed significant overall effectiveness of Telehealth in reducing all-cause mortality (Pandor et al., 2013; Xiang et al., 2013; Inglis et al., 2015; Zhu et al., 2020; Liu et al., 2022; Lee et al., 2022; Mhanna et al., 2022; Ding et al., 2023; Scholte et al., 2023; Masotta et al., 2024; Garanin et al., 2024) and CV (Zhu et al., 2020; Liu et al., 2022; Kuan et al., 2022) or HF related mortality (Wakefield et al., 2013; Kotb et al., 2015; Ruiz-Pérez et al., 2019; Zhu et al., 2020; Liu et al., 2022; Fatrin et al., 2022; Stergiopoulos et al., 2024). Whilst others reported no/neutral differences in all-cause (Zhu et al., 2020; Ramtin et al., 2023; Rebolledo Del Toro et al., 2023; Wang et al., 2024) and HF related mortality (Tsai et al., 2022; Rebolledo Del Toro et al., 2023; Wang et al., 2024) between the intervention and the standard care group.

Similarly, studies showed reduced CHF-related length of stay (Xiang et al., 2013; Tan et al., 2024) in the intervention group while other showed no differences in length of stay (Pandor et al., 2013; Wang et al., 2024) between the intervention and the standard care group.

3.6.3. Extended Follow Up Study

The Telemedical Interventional Management in Heart Failure II (TIM-HF2) trial was a prospective, randomised, multicentre trial done in Germany, and patients were recruited from hospitals and cardiology practices. Eligible patients with HF were randomly assigned (unmasked with randomisation concealment) to either the remote patient management (RPM) group ($n = 796$) or the usual care group ($n = 775$). The results from the main TIM-HF2 trial demonstrated that compared to usual care, a structured RPM intervention, when used in a well-defined population with heart failure over a 12-month period, significantly reduced the percentage of days lost due to unplanned CV hospitalizations and all-cause mortality (Koehler et al., 2018).

Extended follow up—During the extended follow-up period, Patients were followed up for an additional 12 months in a real-world setting and all trial-related procedures were stopped including RPM intervention. The information concerning hospitalisations and mortality was obtained from the patient's health insurance records. The results from the extended follow-up of the trial, revealed that the benefits observed during the initial 12-month intervention period were not sustained after the intervention was stopped. The percentage of days lost due to unplanned CV hospital admissions and all-cause mortality did not differ significantly between groups. However, when data from the main trial and the extended

follow-up period were combined, the percentage of days lost due to unplanned CV hospitalisation or all-cause death was significantly less in RPM group compared to UC group ($P = 0.0486$) (Koehler et al., 2020).

However, the authors highlighted that trial was not initially powered to demonstrate statistical significance during this extended follow-up period, and the results are exploratory.

3.6.4. Interventional Specialized Telemonitoring vs Standard Telemonitoring vs Usual Care

Standard Telemonitoring (STM) involves regular communication with the nurse upon receipt of alerts, where nurses follow up with participants on all concerning flags and alerts and provide additional guidance and advice, and if required request GP consultation whereas in Interventional specialised Telemonitoring (ITM) involves immediate intervention by a cardiology team (face to face or Telehealth appointment).

In a retrospective observation study by Galinier et al., the rate of unplanned hospitalisation, all-cause mortality and CV related mortality rate was lower in ITM-group compared to STM and usual care group. A significant negative association was observed between ITM and unplanned hospitalization [Odds Ratio (OR) = 0.303, 95% Confidence Interval (CI) (0.165 - 0.555, $P < 0.001$], all-causes of mortality [OR = 0.255 95% CI (0.103 - 0.628), $P = 0.003$] and CV mortality [OR = 0.322 95% CI (0.103 - 1.012), $P = 0.052$] (Galinier et al., 2022).

3.6.5. Invasive vs Non-Invasive Home Telemonitoring

Results from meta-analysis conducted by Scholte et al., showed that non-invasive home telemonitoring systems reduces all endpoints such as all-cause mortality, first HF hospitalization, and total HF hospitalizations, whereas in Invasive, only invasive haemodynamic monitoring significantly reduces recurrent HF hospitalizations (10). Overall, in patients using home telemonitoring systems compared with standard of care, a significant 16% reduction in all-cause mortality [pooled odds ratio (OR): 0.84], 19% reduction in first HF hospitalization (OR: 0.81) and a 15% reduction in total HF hospitalizations (pooled incidence rate ratio: 0.85) was observed (Scholte et al., 2023).

3.6.6. Structured Telephone Support (STS) vs Telemonitoring

STS as a transitional care intervention focuses on self-monitoring, education, and self-care management using simple telephone technology, allowing for manual data collection. In contrast, telemonitoring uses digital or wireless transmission of physiological and other non-invasive databases. A number of Systematic Review and Meta-Analysis have described and compared the effectiveness of STS and telemonitoring on patient outcome in individuals with HF (Table 1).

In a systematic review and meta-analysis conducted by Pandor et al., remote monitoring trended to reduce all-cause mortality for STS human-to-human contact (HH) (HR: 0.77), telemonitoring during office hours (HR: 0.76) and telemonitor-

ing 24/7 (HR: 0.49). No beneficial effect on mortality was observed with STS human-to-machine interface (HM). Reductions were also observed in all-cause hospitalisations for telemonitoring interventions but not for STS interventions. No difference in length of stay in patients with both STS and telemonitoring group. STS showed significant improvement in physical and overall measures of QoL (P value < 0.0001) (Pandor et al., 2013).

Table 1. STS Vs Telemonitoring system in individuals with HF.

Ref	STS	Telemonitoring
14	All-cause mortality for STS HH contact + All-cause mortality for STS HM interface – All-cause hospitalisations – Length of stay – Physical and overall measures of QoL +	All-cause mortality during office hours + All-cause mortality TM24/7 + All-cause hospitalisations + Length of stay –
24	HF related mortality + HF-related hospitalisations +	HF related mortality + HF related hospitalizations +
16	All-cause mortality + HF-related hospitalisations + All-cause hospitalisations –	All-cause mortality + HF-related hospitalisations + All-cause hospitalisations –
17	All-cause mortality – All causes hospitalization + Cardiac mortality + HF-related hospitalisations +	All-cause mortality + All-cause hospitalization + Cardiac hospitalization + HF-related mortality –

+ reduces, – No significant impact, human-to-human contact (HH), human-to-machine interface (HM), telemonitoring (TM), Quality of life (QoL).

In another Systematic Review and Meta-Analysis conducted to compare effectiveness of different forms of telemedicine for individuals with HF reported that compared to usual care, STS and telemonitoring both reduced the odds of mortality [STS, (OR): 0.80; telemonitoring, (OR): 0.53] and hospitalizations [STS, OR: 0.69; telemonitoring, OR: 0.64] related to heart failure compared to usual post-discharge care (Kotb et al., 2015). Similarly, a review reported reduction in all-cause mortality (telemonitoring—RR 0.80; STS—RR 0.87) and heart failure-related hospitalisations (telemonitoring—RR 0.71; STS—RR 0.85) in both non-invasive telemonitoring and STS group. It also significantly improved health-related QoL, heart failure knowledge and self-care behaviours. However, neither STS (RR 0.95) nor non-invasive telemonitoring (RR 0.95) demonstrated effectiveness in reducing the risk of all-cause hospitalisations (Inglis et al., 2015).

Zhu et al. reported, reduction in total number of all-cause hospitalization (OR 0.82, $P = 0.0004$), cardiac hospitalization (OR 0.83, $P = 0.007$), and all-cause mortality (OR 0.75, 95% CI 0.62 - 0.90, $P = 0.003$) in the telemonitoring group compared with conventional healthcare. No significant difference in the HF-related mortality (OR 0.84, $P = 0.28$) was observed in the telemonitoring group. Similarly, STS interventions reduced the hospitalization for all causes (OR 0.86, $P = 0.006$) and due to HF (OR 0.74, $P < 0.0001$). A significant effect of telephone support intervention on cardiac mortality (OR 0.54, 95% CI 0.34 - 0.86, $P = 0.009$) was

identified. However no significant effect of telephone support intervention was identified on all-cause mortality (OR 0.96, $P = 0.55$) (Zhu et al., 2020).

4. Discussion

This review included 54 articles (26 original articles and 28 reviews) exploring the impact of Telehealth on outcome such as mortality, hospitalizations, readmission, ED visits, changes in self-care behaviour and QoL, in patients with HF. The existing evidence shows that Telehealth allows for increased support for a greater number of participants, and many of the programs demonstrated considerable effectiveness in areas such as improvement in health-related QoL, heart failure knowledge and self-care behaviours as well as reductions in mortality, hospitalizations, and length of hospital stays.

The Telehealth approaches were diverse, including approaches like face-to-face education followed by phone support to medical or nurse-led interventions. This variety illustrates the evolving landscape of Telehealth and its application in managing chronic conditions like heart failure. Although majority of the studies demonstrated considerable improvement in the patient outcome due to Telehealth intervention (Pedone et al., 2015; Martín-Lesende et al., 2017; Fors et al., 2018; Negarandeh et al., 2019; Mizukawa et al., 2019; Allida et al., 2020; Ware et al., 2020; Yanicelli et al., 2021; Ho et al., 2021; Indraratna et al., 2022; Poelzl et al., 2022; Naik et al., 2022; Knoll et al., 2023; Son et al., 2023), some studies showed little (Wagenaar et al., 2019; Dorsch et al., 2021; Völler et al., 2022) to no improvement (Ong et al., 2016; Smeets et al., 2017; Koehler et al., 2018; Gingele et al., 2019; Park et al., 2019; Baecker et al., 2020). The mixed results observed in these studies can be attributed to clinical heterogeneity among the trials. The type of study design (randomized/non-randomized controlled trial, before and after exploratory study, cohort study, case control study, pragmatic quality improvement study, quasi experimental study) incorporating Telehealth interventions played an important role in these outcomes. There was also variability in the type of intervention used (Structural telephone support, Telemonitoring, Telemonitoring in combination with telephone support, Interventional specialized Telemonitoring, Cardiac implantable electronic devices, Invasive haemodynamic monitoring), follow up duration (ranging from 10 days to 60 months), sample size (ranging from minimum of 30 to a maximum of 26,128) different measurement tools and scales used to measure outcome of interest in the studies. This variability contributes to inconsistent outcomes across different studies. Each paper highlights the need for a multifaceted approach to managing cardiac conditions, addressing both medical and psychological aspects of care.

Tools designed to enhance self-care behaviours utilized social support to motivate patients. This underscores the importance of interactive programs—particularly those focused on education—in improving patients' knowledge and self-management skills. These improvements positively impacted self-care behaviours and health literacy. However, the strategies employed in the studies to boost pa-

patient independence, along with significantly enhanced knowledge and self-care behaviours, did not consistently reduce mortality rates or hospital admission rates. Moreover, despite improvements in QoL of life and self-care behaviours, the usage of Telehealth did not show a significant effect on reducing patients' anxiety or depression levels compared to traditional face-to-face consultations (Lee et al., 2022). There is also insufficient and conflicting evidence to determine how long the effectiveness lasts (Nick et al., 2021). Some studies have shown improvement in the patient outcome over the entire intervention and follow up duration (Mizukawa et al., 2019; Yanicelli et al., 2021; Poelzl et al., 2022; Son et al., 2023) while others have shown improvement in the patient outcome for short term, but not on the long term (Wagenaar et al., 2019; Koehler et al., 2020; Dorsch et al., 2021). The results from the extended follow-up of the trial, revealed that the benefits observed during the initial 12-month intervention period were not sustained after the intervention was stopped (Koehler et al., 2020). Similarly, the results from the "e-Vita HF" randomized controlled trial shows significant improvement in self-care behaviour, health related QoL and HF knowledge at 3 months in patients using intervention. However these effects attenuated during the following 9 months, and no clear differences were seen at 12 months between the groups (Wagenaar et al., 2019). Another randomized controlled trial, using mobile app intervention, showed a greater improvement in health related QoL at 6 weeks, but did not sustain effects at 12 weeks when compared to a control group (Dorsch et al., 2021). To better understand the impact of the Telehealth intervention it's advisable to monitor and assess patient's outcome post intervention for an extensive period.

Studies have demonstrated participant satisfaction with most of the Telehealth interventions. However, there are certain limitations associated with the Telehealth intervention that may hinder patients from using Telehealth such as old age, low-resourced minority populations, individuals requiring translational services, socioeconomic factors, low technological literacy, Internet/Connectivity issues, technical issues, concerns with privacy and confidentiality, limitations with performing comprehensive physical examinations (Drews et al., 2021; Whitelaw et al., 2021; Takahashi et al., 2022; Masterson Creber et al., 2023; Zuchinali et al., 2024; Badr et al., 2024). Consequently, the funding for a Telehealth program can vary significantly, ranging from low costs associated with text messaging to higher costs for renting equipment or using commercial devices. Therefore, when designing and implementing Telehealth intervention, the criteria for inclusion should be more refined considering patients' age, HF severity, comorbidities, patients' self-sufficiency, cognitive responsiveness, and family background.

4.1. Recommendations for Designing or Optimizing Telehealth Programs for HF Patients

To improve the uptake of Telehealth, the services should focus on addressing barriers (related to patient, provider and structural), enhance user experience, educate and upskill patients/caregivers/staff to improve their efficacy in using technology, integrate artificial intelligence (AI) for personalised approach to HF pa-

tient care, develop hybrid care models combining virtual and in-person visits, offer Telehealth services in multiple languages to accommodate diverse populations, regular Monitoring and Evaluation of the program for continuous improvement and further develop sustainable funding models and ensure ongoing support for the Telehealth program.

4.2. Limitation

The purpose of this review was to provide a narrative summary of the articles related to the aims of the study. Although we followed the standard methodology for literature search there is a possibility that we could have missed some of the relevant articles. We also acknowledge the potential for selection bias inherent in a narrative synthesis. However, to reduce the selection bias we explicitly defined and pre-specified inclusion and exclusion criteria and screening (abstract and full text) and data extraction from each article was done by two independent authors.

4.3. Future Directions

Mostly the studies have reported outcome during intervention period or at the end of the intervention. The future studies should evaluate long-term adherence and efficiency of telehealth with follow-up duration spanning several years (exceeding 12 months) post-intervention to directly address the evidence gap on long-term effectiveness. There is also need for more large-scale pragmatic trials to directly evaluate the effectiveness of Telehealth interventions in real-life routine practice conditions using broad patient inclusion criteria for diverse populations.

5. Conclusion

Telehealth interventions have shown a positive impact on patient outcomes, particularly in reducing mortality, hospitalizations and length of hospital stay and potentially improving health-related QoL, heart failure knowledge and self-care behaviours, for individuals with heart failure. However, the effectiveness can vary based on the specific intervention, patient population and study design, highlighting the need for optimization of Telehealth programs.

Authors' Contributions

This study was conceptualized by AH, JH, JC. The search and data extraction were carried out by AH, JH, NM and DV. Articles were screened for inclusion by AH, JH, NM and DV. The analysis was conducted by AH, JH and NM. NM wrote the original draft. All authors were responsible for reviewing and editing the final draft.

Conflicts of Interest

The authors declare no competing interests.

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List of Abbreviations

- CI:** Confidence Interval
- EHFScBS:** European Heart Failure Self-care Behavior Scale
- EQ-5D-5L:** EuroQol 5-Dimension 5-level
- ED:** Emergency Department
- HF:** Heart failure
- HR-QoL:** Health-Related Quality of Life
- ITM:** Interventional Specialised Telemonitoring
- LVEF:** Left Ventricular Ejection Fraction
- MeSH:** Medical Subject Headings
- MLHFQ:** Minnesota Living with Heart Failure Questionnaire
- OR:** Odds Ratio
- QoL:** Quality of Life
- RPM:** Remote Patient Management
- SCHFI:** Self-Care of Heart Failure Index
- STM:** Standard Telemonitoring
- STS:** Structured telephone support
- TM:** Telemonitoring
- TIM-HF2:** Telemedical Interventional Management in Heart Failure II