The Effect of Telemedicine on Readmissions of Patients with Heart Failure and/or COPD: a Systematic Review

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Research Article

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Abstract

**Background** Hospital readmissions pose a challenge for modern healthcare systems. Our aim was to assess the efficacy of telemedicine incorporating telemonitoring technologies in decreasing hospital readmissions with a focus on specific patient populations particularly prone to rehospitalization: patients with heart failure (HF) and/or chronic obstructive pulmonary disease (COPD) through a systematic review.

**Methods** Three major electronic databases, including PubMed, Scopus, and ProQuest’s ABI (Abstracted Business Information)/INFORM Global, were searched for trials employing telemedical technologies and quantifying the effect on the readmission rates in the HF and/or COPD populations. Our search was limited to English-language articles published between 2012 and 2022.

**Results** Eighteen scientific articles referencing seventeen different clinical trials were isolated. Most studies were randomized controlled trials and the readmission related outcome most studied was all-cause readmissions followed by HF and acute exacerbation of COPD readmissions. 47% of the studies suggested that telemedicine might decrease the readmission related burden, while most of the remaining studies suggested that telemedicine had a neutral effect on hospital readmissions. Comparative analysis of studies focusing on the COPD or HF populations resulted in the observation of a clearer association in the reduction of the readmission-related burden in patients with COPD compared to patients with HF (83% vs 27%). Data regarding other relevant outcomes often assessed including all-cause mortality emergency department visits, healthcare costs, quality of life, medication adherence and reconciliation were extracted and qualitatively assessed.

**Conclusion** This systematic review highlights the uncertainty surrounding the effectiveness of telemedicine in reducing the readmission rates of high-risk patients with chronic illnesses, with much of the uncertainty linked to the variability of the deliverable of telemedicine. Nonetheless, the fact that almost all trials found that patients receiving telemedicine benefited to some extent and the strong association in the reduction of readmissions in the COPD population are encouraging. Conduction of more high-quality studies is necessary to draw definitive conclusions.

**Background**

Telemedicine is a multidisciplinary, interactive, and continuously evolving tool first introduced into the medical practice during the past century (1). Recently, the COVID-19 outbreak has promoted and accelerated the incorporation of telemedicine into healthcare systems all over the world (2). Telemedicine is often described as the use of communication networks for the delivery of healthcare services and medical education from one geographic location to another (1). The instruments used by telemedicine often involve communication and/or surveillance technologies (3), with the latter being referred to as telemonitoring (4). Indicatively, some communication tools employed are videoconferences, telephone calls, text messages, and mobile app alerts, while surveillance usually involves vital sign monitoring via Bluetooth automatic medical devices (5).

Identifying patient populations to gain an equitable advantage with telemedicine is vital. One population would, in theory, be those experiencing recent hospitalization. As hospital readmissions pose great economic, social, and psychological issues for patients and their families (6, 7) and still remain one of the main preventable financial strains in modern healthcare systems (8), investigating the effect of telemedicine on hospital readmissions is essential for understanding its potential advantages in healthcare.

Our aim was to conduct a systematic review to assess the current literature on the effectiveness of telemedicine and telemonitoring in reducing the hospital readmissions, particularly, with a specific focus on two chronic conditions accounting for a significant cause of readmissions: heart failure (HF) and chronic obstructive pulmonary disease (COPD) (9, 10). Additionally, we aspired to identify the extent to which patients and healthcare systems might benefit from these interventions.

**Methods**

**Data Sources**

We conducted a systematic review of journal articles published between 2012 and 2022. Data collection was completed on April 5th, 2022. We searched for English-language articles identified through PubMed, Scopus, and ProQuest’s ABI (Abstracted Business Information)/INFORM Global.

**Search Strategy**

Our search strategy on the databases above included the following: hospital readmission(s), patient readmission(s), telemedicine, smartphone(s), telehealth, digital health, eHealth, health application(s), mHealth, health app(s), mobile application(s), mobile app(s), portable electronic app, smartphone app(s) or smartphone. When applicable, we limited the search to adults and excluded wire feeds, blogs, newspapers, magazines, dissertations, and working papers from the results.

**Eligibility Criteria**

Eligibility criteria included studies focusing on the use of any type of telemedicine incorporating remote vital sign monitoring and the association with any readmission-related outcome. Studies that did not use any type of vital sign monitoring (e.g., the only interventions were follow-up calls, texts, and video visits) were excluded as well as systematic reviews or metaanalysis of current data. Additionally, studies not focusing on chronic illnesses such as HF and COPD or studies of the pediatric population.

**Study Identification**
Two persons worked on finalizing the research criteria, and one person reviewed all titles and abstracts identified from the search strategy. Full texts (n = 33) were subsequently independently reviewed by 2 persons independently and 15 additional papers excluded either because the number of patients enrolled in the studies was too small or because the comparison group received some form of treatment different than the telemedicine group. Two studies were excluded because the comparison group was hospitalization or in-person rehabilitation respectively (n = 2). One study was excluded because the comparison group received a telemedical intervention as well (n = 1). The balance of studies was eliminated because they were feasibility (n = 4), pilot (n = 5), or analysis of systems (n = 1) studies enrolling only a small number of patients (on average less than 40 patients). Furthermore, two papers (n = 2) were excluded as they did not study the readmission rate either as the primary or secondary endpoint of the study (Fig. 1).

Data extraction

Data extracted from full-text articles (n = 18) included: first author's name, year of publication, country where the study took place, disease of the patient population studied, type of study, type of telemedical intervention, comparison group intervention (if any), number of patients enrolled in each group, primary and secondary endpoints of the studies, study outcomes related to readmissions, and other relevant study outcomes.

Qualitative analysis

During data extraction, we realized that many studies used different ways to quantify the effect of telemedicine on readmissions. We concluded that a more accurate analysis would stem from the study of the rate of readmissions (all-cause or disease-specific), time to first readmission (all-cause or disease-specific), as well as the duration of hospitalization (all-cause or disease-specific). Furthermore, we assessed the results of the outcome most frequently studied which was all-cause readmissions (n = 12), and the results of the prospective studies that had a readmission-related outcome as the primary endpoint of the study. Additionally, we analyzed other outcomes of the studies that were either related to the healthcare burden such as emergency department (ED) visits, outpatient visits, and total healthcare cost, or related to patient benefit, such as mortality, quality of life (QoL) (usually assessed with standardized questionnaires), medication adherence, and medication reconciliation.

Results

The data extracted from the articles isolated after the application of exclusion criteria (n=18) are displayed in Table 1 and refer to seventeen different trials (11-28). Two of the articles refer to the same trial (short- and long-term analysis), so their data are presented in the same table row. The vast majority of these studies were conducted in Europe and North America (n=14) and most focused on HF (n=10) and fewer focused on COPD (n=5). Additionally, one study enrolled patients with HF and COPD (n=1) and another study patients with 2 or more chronic diseases (n=1). Most studies were randomized controlled trials (RCT) (n=10). Some were non-RCT (n=4) and fewer were retrospective (n=3), including a cohort following an RCT (n=1), a retrospective analysis (n=1), and a retrospective case-control (n=1) study. The telemonitoring parameters most monitored were heart rate (HR) (n=13), body weight (n=12), blood pressure (BP) (n=10), and oxygen saturation (Ox Sat) (n=7) while respiratory rate (RR) (n=1), and electrocardiogram (ECG) (n=2) monitoring were employed less frequently. Additionally, some studies subjected patients to daily questionnaires and clinical questions (n=5). Notably, a small fraction of the studies combined telemonitoring with telerehabilitation (n=2).

Table 1: Overview of the results.
<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>Disease</th>
<th>Type of Study</th>
<th>Telemedical Intervention</th>
<th>Comparison Group</th>
<th>No. of Patients</th>
<th>Outcomes (Primary or Secondary Endpoint)</th>
<th>Readmission-Related Outcomes (Rate/Timeto/ Duration) (Primary or Secondary Endpoint)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marcos et al, 2022</td>
<td>Spain</td>
<td>COPD</td>
<td>Non-RCT</td>
<td>Telemonitoring (HR, Ox sat, clinical questions)</td>
<td>Usual care (historical control) (n=495)</td>
<td>351</td>
<td>All-cause mortality or readmissions (Primary)</td>
<td>Statistically significant reduction in all-cause mortality or readmission after 12 months (35.2% vs. 45.2%, Haz R of 0.71 [95% CI=0.56-0.91], p=0.007) (Primary)</td>
</tr>
<tr>
<td>Dorsch et al, 2021</td>
<td>USA</td>
<td>HF</td>
<td>RCT</td>
<td>Telemonitoring (weight, physical activity) + mobile app</td>
<td>Usual care (n=41)</td>
<td>42</td>
<td>6- and 12-week ΔMLHFQ score (Primary)</td>
<td>No significant difference in time to first HF-readmission. (Secondary)</td>
</tr>
<tr>
<td>Noel et al, 2020</td>
<td>USA</td>
<td>2 or more chronic diseases</td>
<td>RCT</td>
<td>Telemonitoring (HR, BP, Ox sat, weight)</td>
<td>Usual care (n=57)</td>
<td>45</td>
<td>All-cause readmissions, ED visits (Primary)</td>
<td>No significant difference in all-cause readmissions (Primary)</td>
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<td></td>
<td></td>
<td></td>
<td>medication adherence, reconciliation, mortality (Secondary)</td>
<td></td>
</tr>
<tr>
<td>Leng-Chow et al, 2020</td>
<td>Singapore</td>
<td>HF</td>
<td>Non-RCT</td>
<td>Telemonitoring (HR, BP, weight, questionnaires) + health coaching (interactive device)</td>
<td>Usual care + structured telephone support (n=55)</td>
<td>150</td>
<td>All-cause and HF readmissions, all-cause HF bed days, all-cause one-year mortality, and cost</td>
<td>No significant differences in all-cause and HF readmissions</td>
</tr>
<tr>
<td>Srivastava et al, 2019</td>
<td>USA</td>
<td>HF</td>
<td>Retrospective case-control</td>
<td>Telemonitoring (HR, BP, weight)</td>
<td>Usual care group (n=870) and self-1-year before telemonitoring initiation</td>
<td>197</td>
<td>All-cause/ HF-readmissions, total hospital days per patient, length of stay per admission, urgent care, ED and primary care visits</td>
<td>No significant differences in all-cause and HF readmissions significant reduction in the length of hospital stay in the telemedicine group (5.7 vs 9.0, p &lt; 0.01)</td>
</tr>
<tr>
<td>Author et al., Year</td>
<td>Location</td>
<td>Condition</td>
<td>Study Design</td>
<td>Intervention</td>
<td>Control</td>
<td>Patient Count</td>
<td>Primary Outcome</td>
<td>Secondary Outcome</td>
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<tr>
<td>Bhatt et al., 2019</td>
<td>USA</td>
<td>COPD</td>
<td>Non-RCT</td>
<td>Telemonitoring (HR, BP, Ox Sat.) in relation to tele-pulmonary rehabilitation (smartphone foot pedaler (+/- treadmills, exercise bikes))</td>
<td>Usual care (matched by readmission risk/not randomized) (n=160)</td>
<td>80</td>
<td>30-day all cause readmissions (Primary)</td>
<td>Significant reduction 30-day all-cause readmission rate (6.2 vs 18.1%, p=0.015) (Primary), significant reduction in 30-day AECOPD readmission rate (3.8 vs 11.9% p=0.04) (Secondary)</td>
</tr>
<tr>
<td>Dendale et al., 2012</td>
<td>Belgium</td>
<td>HF</td>
<td>RCT</td>
<td>Telemonitoring (HR, BP, weight)</td>
<td>Usual care (n=80)</td>
<td>80</td>
<td>All-cause mortality (Primary)</td>
<td>Significant reduction total days lost due to hospitalization (13 vs 30, p= 0.02), the reduction was maintained in the long-term analysis (7.28 vs 11.81, p=0.04)</td>
</tr>
<tr>
<td>Frederix et al., 2019</td>
<td></td>
<td>HF</td>
<td>RCT</td>
<td>Usual care (n=80)</td>
<td>80</td>
<td>All-cause mortality (Primary)</td>
<td>Days lost due to HF readmissions, days lost to death, hospitalization, or dialysis, related costs comparison, and number of hospitalizations (Secondary)</td>
<td>No significant difference in HF readmissions (Primary), no significant reduction in all-cause and cardiovascular readmissions (Secondary)</td>
</tr>
<tr>
<td>Kotooka et al., 2018</td>
<td>Japan</td>
<td>HF</td>
<td>RCT</td>
<td>Telemonitoring (HR, BP, weight, body composition)</td>
<td>Usual care (n=91)</td>
<td>90</td>
<td>HF- readmissions and all-cause mortality (Primary)</td>
<td>No significant difference in HF readmissions (Primary), no significant reduction in all-cause and cardiovascular readmissions (Secondary)</td>
</tr>
<tr>
<td>Bernocchi et al., 2018</td>
<td>Italy</td>
<td>HF + COPD</td>
<td>RCT</td>
<td>Telemonitoring (HR, Ox Sat, ECG) + tele-rehabilitation + educational interventions</td>
<td>Usual care(n=56)</td>
<td>56</td>
<td>Exercise tolerance (6MWT) (Primary)</td>
<td>Significant increase in the median time to hospitalization (readmission) or death (113.4 vs 104.7 days, p= 0.0484)</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Condition</td>
<td>Design</td>
<td>Intervention Details</td>
<td>Control</td>
<td>Comparator</td>
<td>Outcomes (Primary)</td>
<td>Outcomes (Secondary)</td>
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<td>Ong et al, 2016</td>
<td>USA</td>
<td>HF</td>
<td>RCT</td>
<td>Telemonitoring (HR, BP, weight) + health coaching (telephone calls, interactive device)</td>
<td>Usual care (n=722)</td>
<td>715</td>
<td>180-day all-cause readmissions</td>
<td>No significant difference in 180-day all-cause readmission (Primary)</td>
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<td>30-day all-cause readmission</td>
<td>No significant difference in 30-day all-cause readmission (Secondary)</td>
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<td>30- and 180-day mortality</td>
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<td></td>
<td>QoL (MLHFQ, CAT)</td>
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<tr>
<td>Esteban et al, 2016</td>
<td>Spain</td>
<td>COPD</td>
<td>Non-RCT</td>
<td>Telemonitoring (HR, RR, Ox Sat, questionnaires) + mobile app + patient education</td>
<td>Usual care (n=78)</td>
<td>119</td>
<td>AECOPD readmission rate, length of stay, readmission rate within 30 days</td>
<td>Significant reduction AECOPD readmission (OR 0.38, 95% CI 0.27–0.54, p&lt;0.0001) (Primary), 30-day all-cause readmissions (OR 0.49, 95% CI 0.29–0.74, p&lt;0.001) and length of hospital stay, (OR 0.59, 95% CI 0.46–0.73, p&lt;0.0001) (Secondary)</td>
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<td></td>
<td>ED visits, mortality, QoL, exercise capacity, limitations in daily life</td>
<td></td>
</tr>
<tr>
<td>Ho et al, 2016</td>
<td>Taiwan</td>
<td>COPD</td>
<td>RCT</td>
<td>Telemonitoring (HR, BP, Ox Sat, temperature, weight) + symptom diary</td>
<td>Usual care (n=53)</td>
<td>53</td>
<td>Time to first AECOPD readmissions within 6 months</td>
<td>Significant increase in time to first AECOPD readmission within 6 months (p=0.02) (Primary), all-cause readmissions (0.23 vs. 0.68/patient = 0.002) (Secondary)</td>
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<td>ED visits</td>
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<tr>
<td>Kraai et al, 2016</td>
<td>Netherlands</td>
<td>HF</td>
<td>RCT</td>
<td>Telemonitoring (HR, BP, weight, ECG) + ICT-guided- DMS</td>
<td>ICT-guided- DMS (n=83)</td>
<td>94</td>
<td>Mean composite endpoint score</td>
<td>No significant difference in all-cause readmissions (Secondary)</td>
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<td></td>
<td></td>
<td>all-cause readmissions, all-cause mortality, QoL, HF outpatient clinic visits, cost analysis</td>
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<tr>
<td>Hofmann et al, 2015</td>
<td>Germany</td>
<td>HF</td>
<td>RCT</td>
<td>Telemonitoring (HR, BP, weight, questionnaires) + health coaching (interactive device)</td>
<td>Usual care (n=319)</td>
<td>302</td>
<td>Days alive neither in hospital nor inpatient care per potential days in study, incremental cost-effectiveness ratio</td>
<td>No significant difference in days alive neither in hospital nor inpatient care per potential days (Primary)</td>
</tr>
</tbody>
</table>
usually failing to understand the initial signs of decompensation is one of the most common causes of hospital readmissions (35, 36). The signs of early systemic congestion (33). Studies suggest that about a quarter of patients with HF are readmitted within 30 days upon discharge (34). Moreover, patients (ADHF) is often referred to as new or worsening signs and symptoms of HF that often lead to ED visits or hospitalizations and is usually associated with the cardiac function (31) accounting for approximately 1-2% of all hospital admissions in Europe and North America (32). Acute decompensated HF is one of the most prevalent diseases with more than 38 million people suffering worldwide (30) and is characterized by recurrent hospitalizations due to decompensation in all-cause mortality (n=2), ED visits (n=2), healthcare costs (n=2), QoL (n=2), and medication adherence (n=1).

Discussion

With this systematic review, we aimed to evaluate the current evidence on the effectiveness of telemedicine in reducing the readmission burden of patient populations with chronic conditions placing them at high risk for re-hospitalization. The most studied populations were patients with HF and/or COPD. HF is a clinical syndrome in which symptoms occur due to functional or structural impairment of ventricular filling or ejection of blood (29). It is one of the most prevalent diseases with more than 38 million people suffering worldwide (30) and is characterized by recurrent hospitalizations due to decompensation of the cardiac function (31) accounting for approximately 1-2% of all hospital admissions in Europe and North America (32). Acute decompensated HF (ADHF) is often referred to as new or worsening signs and symptoms of HF that often lead to ED visits or hospitalizations and is usually associated with systemic congestion (33). Studies suggest that about a quarter of patients with HF are readmitted within 30 days upon discharge (34). Moreover, patients usually failing to understand the initial signs of decompensation is one of the most common causes of hospital readmissions (35, 36). The signs of early ADHF could be easily identified with BP, HR, Ox sat, and weight monitoring and treated efficiently by adjustment of the patient's medication regimen.
preventing a hospital readmission. Daily monitoring of patients in the outpatient setting could be feasible solely with the assistance of telemedicine this is why telemedicine is considered to have a promising role in the patient management following an ADHF episode (37).

However, our systematic review pointed out that 73% (n=8) of the studies focusing on the HF population (n=11) did not demonstrate any statistically significant effect on readmissions in the intervention group. The remaining 27% of them (n=3) found telemedical interventions to be effective at decreasing either the duration of the readmissions, rate of readmissions, or increasing the time to first readmission. Ambiguous were the results of these studies regarding the effect of telemedicine on QoL, ED visits, and mortality as well. Furthermore, the HF studies examining the difference in overall healthcare costs (n=2) concluded that telemedicine did not have a significant effect on healthcare-related cost reduction.

COPD is characterized by persistent airflow limitation due to airway and/or alveolar abnormalities with the most common risk factor being tobacco smoking (38). AECOPD, as defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) is an acute event characterized by a worsening of the patient’s respiratory symptoms that is beyond normal day-to-day variations and leads to a change in medication (38). Patients with AECOPD often require hospitalization (39) which accounts for about 70% of total COPD-related medical costs (40). Apart from the great financial burden, AECOPD might have potentially severe consequences for the patients, such as a decline in pulmonary function (41) and an increase in mortality (42). The rate of readmissions following an AECOPD is particularly high, notably, a study conducted in the US found a 64% readmission rate after a discharge for an AECOPD in Medicare beneficiaries (43). The high rate of readmissions propagating the financial, psychological, and medical load alongside the patients’ difficulty in recognizing the early symptoms of deterioration (44) mandate the need for the development of an effective system to recognize the onset of an exacerbation timely and suggest that patients with COPD would benefit from telemedical monitoring. The telemedical devices usually monitor O2 sat, HR, RR, and temperature, as well as ask standardized questions regarding the patient’s symptoms to evaluate for an AECOPD.

Our results suggest that readmissions of patients with COPD could potentially be reduced in patients being monitored with teledemical devices in the outpatient setting. Specifically, out of the 6 COPD studies identified 83% (n=5) concluded that the telemedical intervention either decreased (all-cause or AECOPD) readmissions, increased time to readmission, or decreased length of hospital stay during each readmission. Only one retrospective study (17%) suggested that people in the telemedicine group were more likely to be readmitted to the hospital. Furthermore, two of these studies suggested that telemedicine decreased ED visits. These data regarding the effectiveness of telemedicine on readmissions of patients with COPD seem optimistic but more studies providing high-quality evidence are necessary to validate these conclusions. Notably not all 6 COPD studies were optimally designed since three of them were non-RCT and one was retrospective.

Limitations

This systematic review is subject to many of the common limitations and biases similar studies experience. Our selection criteria may have screened out studies that could potentially alter our results. Additional selection bias could be introduced as we focused on studies published only in the English language during 2012-2022. Furthermore, the lack of access to unpublished data could as well impose a publication bias on our study. Regarding the quality of the studies analyzed, even though most were RCT, not all had a readmission-related outcome as a primary endpoint and some examined a specific patient population (e.g., veterans or residents of a particular geographical region) that may pose challenges to extrapolate to other populations. Our study is further limited by the inclusion of international studies; healthcare systems vary significantly, and there are substantial differences in how each country allocates resources, manages readmissions, or delivers outpatient care. Another limitation of the studies of telemedicine, in general, is the exclusion of a patient group not willing or able to use the employed technologies.

Conclusions

In this systematic review, we performed a literature review to provide a comprehensive overview of the effect of telemedicine on hospital readmissions in high-risk patients with chronic diseases, particularly, HF and COPD. It is evident from our analysis that no definitive conclusion can be drawn yet, but there was a clearer trend in patients with COPD benefiting from the telemedical intervention compared to patients with HF. Additionally, most of the studies suggest that telemedicine could positively impact patients’ lives. We believe that shortly with the incorporation of novel telemonitoring technologies and with the initiation of studies that employ reproducible health systems approaches in telehealth services for at-risk populations, both of which have been prioritized due to the recent COVID-19 public health crisis, telehealth will be a transformative intervention for the care of at-risk cardiopulmonary patients.

Abbreviations

Abstracted Business Information (ABI), Acute decompensated HF (ADHF), Acute exacerbation of COPD (AECOPD), Blood pressure (BP), Chronic obstructive pulmonary disease (COPD), COPD Assessment Test (CAT), Confidence Interval (CI), Electrocardiogram (ECG), General Self-Efﬁcacy Scale (GSES), Global Initiative for Chronic Obstructive Lung Disease (GOLD), Hazard ratio (Haz R), Heart failure (HF), Heart rate (HR), Information and Computing Technology-guided-disease-management system (ICT-guided-DMS), Kansas City Cardiomyopathy Questionnaire (KCCQ), Medical Research Council (MRC), Minnesota Living With Heart Failure Questionnaire (MLHFQ), Mini Mental State Examination (MMSE) score, Odds ratio (OR), Oxygen saturation (O2 sat), Physical Activity Scale for the Elderly (PASE), Patient Health Questionnaire (PHQ-9), Quality of Life (QoL), Randomized controlled trial (RCT), Respiratory rate (RR), Self-Care Heart Failure Index (SCHFI), Short Form-36 (SF-36), World Health Organization Well Being Index (WHO-5), 6-min walk test (6MWT).

Declarations
Ethics approval and consent to participate
Not applicable

Consent for publication
Not applicable

Availability of data and materials
The databases supporting the findings of our systematic review are available for further analysis. The data sources include ProQuest’s ABI/INFORM Global (https://about.proquest.com/en/products-services/abi_inform_global/), PubMed (https://pubmed.ncbi.nlm.nih.gov/) and Scopus (https://www.scopus.com/search/form.uri?display=basic#basic). The research criteria applied during the study are thoroughly detailed in the “Methods” section of our manuscript. Researchers interested in accessing and utilizing the datasets for validation or additional analysis can contact PG (pgaliat1@jhmi.edu) for assistance.

Competing interests
Not applicable

Funding
Not applicable

Authors’ contributions
Conceptualization: PG
Review of the Literature and Data Extraction: GS, PG
Writing- original draft: GS
Writing- review & editing: GS, AE, EC, PG

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References


Figures

Figure 1

Flowchart depicting the process of the literature search of the systematic review.