

TITLE: Telehealth for Patients with Heart Failure: A Review of the Clinical Effectiveness, Cost-effectiveness and Guidelines

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CONTEXT AND POLICY ISSUES

Heart failure, often referred to as congestive heart failure, is a chronic, common and costly condition that is diagnosed in 1 to 2% of the general population in industrialized countries, with mortality and hospitalization rates among the highest of medical conditions.¹

The management of heart failure requires continuous care, and extends to professional services delivered to patients' home via some form of telehealth technology with the aim to keep patients well and reduce unnecessary hospital admissions. Telehealth is a broad term used to describe a range of communication and information technologies that aim to provide professional health care advices and services from a distance.^{2,3} Telehealth may include telecommunications technologies such as the Internet, telephone, or videoconferencing to transmit physiological data from the patient to health care professionals), structured telephone support, and telemonitoring using a monitor device with digital, broadband, satellite, wireless, or blue-tooth transmission).⁴ In Canada, with an increase in the aging population, there may be a greater need for remote patient monitoring due to an increase in chronic conditions.⁵

This Rapid Response report aims to review the clinical- and cost-effectiveness of telehealth for patients with heart failure. Guidelines associated with the use of telehealth in the management of heart failure will also be examined.

RESEARCH QUESTIONS

1. What is the clinical evidence regarding telehealth interventions for patients with heart failure requiring cardiac care?
2. What is the cost-effectiveness of telehealth interventions for patients with heart failure requiring cardiac care?

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3. What are the evidence-based guidelines regarding telehealth interventions for patients with heart failure requiring cardiac care?

KEY FINDINGS

In general, the use of telehealth such as structured telephone support or home telemonitoring using telecommunications technologies contributed to reductions in hospitalizations and mortality, and improved quality of life and lifestyle behaviour. A limited amount of evidence on cost-effectiveness showed inconsistent findings on the cost-effectiveness of telehealth compared to usual care. In Canada, the use of a Health Lines intervention (nurses available on telephone to provide suggestions) may be more cost-effective than usual care. There were no evidence-based guidelines identified regarding telehealth interventions for patients with heart failure requiring cardiac care.

METHODS

Literature Search Strategy

A limited literature search was conducted on key resources including PubMed, The Cochrane Library, University of York Centre for Reviews and Dissemination (CRD) databases, ECRI, Canadian and major international health technology agencies, as well as a focused Internet search. Methodological filters were applied to limit retrieval to health technology assessments, systematic reviews, meta-analyses, economic studies, and guidelines. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2013 and November 23, 2015.

Selection Criteria and Methods

One reviewer screened citations and selected studies. In the first level of screening, titles and abstracts were reviewed for relevance. Full texts of any relevant titles or abstracts were retrieved, and assessed for inclusion. The final article selection was based on the inclusion criteria presented in Table 1.

Population	Patients with heart failure requiring cardiac care
Intervention	Telemedicine interventions (e.g. Video conferencing, Home health monitoring, Telehealth phone lines, Digital medical devices [e.g. digital stethoscope]) for assessment and follow-up
Comparator	Standard care (in person consultation and/or assessment)
Outcomes	Clinical benefits or harms (improved health outcomes, improved access to care, patient experience, travel time, avoidance of transfer) Cost-effectiveness (both health care system and impact on patients/families) Guidelines for use of telemedicine (including optimal types of patients or those for whom it would not be recommended)

Study Designs

Health technology assessments (HTA), systematic reviews (SR), and meta-analyses (MA), economic evaluations, and guidelines

Exclusion Criteria

Articles were excluded if they did not meet the selection criteria in Table 1, if they were published prior to January 2013, if they were duplicate publications of the same study, or if they were referenced in a selected systematic review.

Critical Appraisal of Individual Studies

The quality of the included systematic reviews and cost studies was assessed using the AMSTAR⁶ and Drummond⁷ checklists, respectively. Numeric scores were not calculated. Instead, the strengths and limitations of the study are summarized and presented.

SUMMARY OF EVIDENCE

Quantity of Research Available

The literature search yielded 387 citations. After screening of abstracts from the literature search and from other sources, 85 potentially relevant studies were selected for full-text review. Five studies on telehealth for heart failure were included in the review. The PRISMA flowchart in Appendix 1 details the process of the study selection.

Summary of Study Characteristics

A detailed summary of the characteristics of the included SRs and cost studies is provided in Appendix 2 and 3, respectively.

Study design

One study was a narrative systematic review of systematic reviews,⁸ one study was a narrative systematic review of experimental or quasi-experimental trials,⁹ one study was a systematic review/meta-analysis of randomized-controlled trials,¹⁰ and two studies were cost-effectiveness studies.^{11,12} Both cost-effectiveness studies performed a cost analysis, and cost-effectiveness was expressed as the incremental cost-effectiveness ratio (ICER, or the extra monetary resources needed for the intervention to gain one extra quality-adjusted life year (QALY) compared to usual care).^{11,12}

Population

Two systematic reviews on the clinical effectiveness of telehealth included adult patients with known heart failure.^{8,10} The systematic review on the effectiveness of telehealth on behavioural changes included patients of any age diagnosed with any type of cardiovascular diseases. The cost-effectiveness studies included patients with heart failure who were older than 18 years old¹¹ or aged 40 and over.¹²

Interventions and comparators

The systematic reviews on clinical effectiveness evaluated telemonitoring (telecommunications technologies such as the Internet, telephone, or videoconferencing to transmit physiological data from the patient to health care professionals),⁸ or structured telephone support (simple telephone technology) and telemonitoring (digital, broadband, satellite, wireless, or blue-tooth transmission).¹⁰ The systematic review on behavioural changes evaluated the use of mobile wireless devices (mobile phones) capable of receiving text messages to deliver health education, recommendations or motivational messages.⁹ One cost study evaluated a telemonitoring device (Health Buddy),¹¹ which is a device connected to a telephone line. Patients received daily preset dialogues and questions about symptoms, knowledge and behaviour, which had to be answered (positive answers for symptoms were considered high risk, and triggered action by the nurse). One cost study evaluated health line interventions (telephones) and in-house monitoring (monitoring devices, unspecified).¹² The comparator in all included studies was usual care.

Outcomes

The systematic review of systematic reviews⁸ reported all-cause and heart failure-related hospitalizations, length of hospital stay, all-cause mortality, and quality of life. The systematic review / meta-analysis¹⁰ reported all-cause and heart failure-related hospitalizations, length of hospital stay, all-cause mortality, quality of life, adherence to medication, heart failure knowledge, and self-care behaviours. Quality of life, knowledge and self-care were assessed using validated questionnaires. There was no description of how adherence to medication was assessed. The systematic review on mobile phones⁹ reported changes in lifestyle behaviour such as physical activity, diet, smoking, alcohol use, and medication adherence. The two cost studies^{11,12} reported costs and cost-effectiveness. The cost studies performed cost analyses from the health care perspective which included all costs inside the health care sectors.

Summary of Critical Appraisal

Two of the included systematic reviews are narrative reviews,^{8,9} with a priori design provided, duplicate study selection and data extraction procedure in place, comprehensive literature search performed, list of included studies, study characteristics provided, quality assessment of included studies provided and used in formulating conclusions, and conflict of interest stated. No assessment of publication bias was performed, and considerable heterogeneity in the interventions was reported in the included studies. A list of excluded studies was not provided in one systematic review.⁸ The systematic review/meta-analysis¹⁰ had a priori design provided, duplicate study selection and data extraction procedure in place, comprehensive literature search performed, list of included studies, study characteristics provided, list of excluded studies provided, quality assessment of included studies provided and used in formulating conclusions, assessment of publication bias performed, and conflict of interest stated.

The included cost studies^{11,12} are likely to be usable, outcomes and costs were assessed and appropriately compared, sources for cost were provided, an incremental analysis of the outcomes, costs of alternatives and a sensitivity analysis was performed, and the presentation and discussion of study results include all issues of concern to users. The Canadian cost study¹² helped in the generalizability of the results to the Canadian system, but used 2005 Can\$; the figures need to be interpreted with caution.

Details of the strengths and limitations of the included studies are summarized in Appendix 4.

Summary of Findings

The main findings of included studies are summarized in detail in Appendix 5.

1. What is the clinical evidence regarding telehealth interventions for patients with heart failure requiring cardiac care?

The literature search found one systematic review of systematic reviews,⁸ one Cochrane systematic review/meta-analysis,¹⁰ and one narrative systematic review⁹ that met the inclusion criteria for this report. In general, the use of telehealth such as structured telephone support or home telemonitoring using telecommunications technologies contributed to reductions in hospitalizations and mortality, and improved quality of life and lifestyle behaviour.

A systematic review of systematic reviews⁸ included nine reviews on telemonitoring in the management of heart failure for adult patients (eight reviews reported hospitalizations, five reported length of stay, six reported mortality and six reported quality of life). All reviews reported that telemonitoring was associated with reduced all-cause and heart failure-related hospitalizations, and reduction in all-cause mortality. All reviews reported improved quality of life. The reviews reported conflicting findings in length of hospital stay. The authors concluded that telemonitoring contributes to significant reductions in all-cause and heart failure-related hospitalizations and all-cause mortality, and improved quality of life.

A Cochrane systematic review/meta-analysis¹⁰ included 41 RCTs on either structured telephone support or home telemonitoring for adult patients with heart failure. The duration of the intervention was not reported. Pooled estimates showed that structured telephone support reduced the risk for all-cause mortality by 13% (relative risk [RR] 0.87; 95% confidence interval [CI] 0.77 to 0.98, pooled estimate from 22 studies; 9222 participants) and the risk for heart failure-related hospitalizations by 15% (RR 0.85; 95% CI 0.77 to 0.93, pooled estimate from 13 studies; 7030 participants).

Pooled estimates showed that telemonitoring reduced the risk for all-cause mortality by 20% (RR 0.80; 95% CI 0.68 to 0.94, pooled estimate from 17 studies; 3740 participants) and the risk for heart failure-related hospitalizations by 29% (RR 0.71; 95% CI 0.60 to 0.83, pooled estimate from eight studies; 2148 participants).

All-cause hospitalization was not reduced by either structured telephone support (RR 0.95; 95% CI 0.90 to 1.00, pooled estimate from 16 studies; 7216 participants) or telemonitoring (RR 0.95; 95% CI 0.89 to 1.01, pooled estimate from 13 studies; 3332 participants).

One out of seven studies on structured telephone support, and one out of nine studies on telemonitoring reported a statistically significant reduction in length of hospital stay (no meta-analysis performed).

Nine out of 11 studies on structured telephone support and five out of 11 studies on telemonitoring reported a statistically significant improvement in health-related quality of life (QOL) outcomes (no meta-analysis performed). An adherence rate of 55.1% to 65.8% was shown for structured telephone support (data from three studies) and 75.0% to 98.5% for

telemonitoring (data from eight studies). All studies except one on structured telephone support reported significant improvement in heart failure knowledge (6 studies on structured telephone support and one study on telemonitoring). All studies reported significant improvement in self-care (4 studies on structured telephone support and one study on telemonitoring). The authors concluded that structured telephone support and home telemonitoring reduce the risk of all-cause mortality and heart failure-related hospitalizations; these interventions also improved health-related quality of life, heart failure knowledge and self-care behaviours.

A narrative systematic review was identified on the effectiveness of mobile phones (mHealth) on behavioural changes in patients of any age diagnosed with any type of cardiovascular diseases.⁹ Seven studies were included with the intervention duration ranging from 30 days to 12 months. Five studies reported physical activity (3 studies), and medication adherence (2 studies). All five studies found increased physical activity behaviour and adherence to medication. One study reported dietary habits and one study reported smoking habits. No study found positive treatment effect on dietary habits, or smoking cessation. The authors concluded that mHealth has the potential to change lifestyle behaviour.

2. What is the cost-effectiveness of telehealth interventions for patients with heart failure requiring cardiac care?

The literature search identified two cost-effectiveness analyses^{11,12} on telehealth in patients with heart failure that met the inclusion criteria for this review. In general, the use of a telemonitoring device in three hospitals in The Netherlands did not show a statistically significant difference in annual cost per patient between the intervention and usual care groups after one year follow-up, and cost-effectiveness showed a high level of decision uncertainty. The use of a Health Lines intervention (nurses available on telephone) or Health Lines plus in-home monitoring with monitoring devices showed that both options cost less and were more effective than usual care in Canada, with the use of Health Lines alone being the most cost-effective among all options.

A cost-effectiveness study conducted in The Netherlands (published in 2013) included 382 adult patients with congestive heart failure randomly allocated to telemonitoring (using the telemonitoring device Health Buddy, Sananet, Sittard, The Netherlands), or usual care.¹¹ There was no mention of the year in which the costs were based on for the calculations. After one year of follow-up, there was no significant difference in health-related quality of life between telemonitoring group and usual care group (utility scores improved by 0.07 points for the usual care group and 0.1 points for the telemonitoring group). There were no significant differences in annual costs per patient between the two groups (€16,561 in the usual care group and €16,687 in the telemonitoring group) (all costs inside the health care sector were included, e.g., device-related costs, hospital procedure costs, home care costs, and medication costs). Cost-effectiveness analyses showed that, at a willingness-to-pay threshold of €50,000, there is a 48% probability that telemonitoring is cost-effective. The ICER for telemonitoring versus usual care was €40,321 per QALY gained). The authors concluded that the cost-effectiveness analysis showed a high level of decision uncertainty, and it is therefore premature to draw an unambiguous conclusions regarding cost-effectiveness for the intervention.

A cost-effectiveness study conducted in Manitoba, Canada (published in 2013) included 179 adult patients with congestive heart failure randomly allocated to standard care (group 1), standard care plus Health Lines (group 2), or standard care plus Health Lines with in-house

monitoring with monitoring devices (group 3). The differences in costs per patient (2005 Can \$) including both health care utilization and intervention costs were not statistically significant between the three groups (usual care: \$7,151; Health Lines intervention: \$6,430; Health Lines plus in-house monitoring: \$6,311)

The Health Line intervention and Health Lines plus in-house monitoring are more cost-effective than usual care. At a willingness-to-pay threshold of \$50,000, there is an 85.8% probability that Health Line intervention is cost-effective. The Health Line intervention was more cost-effective than Health Line intervention plus in-house monitoring (ICER for health line interventions versus health line interventions plus in-house monitoring: Can\$2,975 per QALY gained). The authors concluded that the Health Lines intervention is more likely to be cost-effective in the management of congestive heart failure compared to usual care or Health Lines plus home monitoring interventions.

3. What are the evidence-based guidelines regarding telehealth interventions for patients with heart failure requiring cardiac care?

There were no evidence-based guidelines identified regarding telehealth interventions for patients with heart failure requiring cardiac care.

Limitations

One limitation in the included clinical effectiveness systematic reviews is the heterogeneity of the interventions used in the included trials and reviews. Meta-analyses pooled data from older and newer studies using different technologies without subgroup analyses based on different technologies. Included systematic reviews found inadequate reporting by many trials which precluded classification of risks of bias. The cost-effectiveness studies had limited data sample sizes and costs may have been calculated based on old currency values or outdated costs. There is no evidence found regarding the evidence-based guidelines regarding telehealth interventions for patients with heart failure requiring cardiac care.

CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

The use of telehealth such as structured telephone support or home telemonitoring using telecommunications technologies may contribute to reductions in hospitalizations and mortality, and improved quality of life and lifestyle behaviour in patients with heart failure. Evidence is inconclusive on the cost-effectiveness of telehealth compared to usual care. In Canada, the use of Health Lines (nurses available on telephone to provide suggestions) may be more cost-effective than usual care. There were no evidence-based guidelines identified regarding telehealth interventions for patients with heart failure requiring cardiac care.

In addition to telehealth use, patients' training before discharge from hospital is essential, including training about heart failure and its treatment, diet, exercise, self-monitoring and self-management, and methods of connecting with health care workers by telecommunication technologies. Pre-discharge training was shown to make a positive difference in the readmission rates for patients with heart failure.¹³

Despite the evidence on the clinical effectiveness of telehealth, patients and staff acceptance of telehealth is an important but not well-studied factor, leading to a potential underuse of telehealth¹⁴. Many patients feel that they are unable to operate monitoring devices, telemonitoring may undermine their sense of identity, and the time taken to complete daily monitoring is a barrier to adherence.¹⁵ Many patients also believe that telemonitoring disrupts the relationship with their physician and fosters social isolation,^{16,17} while factors affecting front-line staff were identified as the negative impact of service change (e.g. burden to the nursing staff), staff-patient interaction (staff commented that job satisfaction came from face-to-face contact with patients), credibility and autonomy (nurses often viewed telehealth as extra responsibility), and technical issues.¹⁸ A successful adaptation of telehealth and fruitful outcomes require an analysis of needs and education on both patients and staff.

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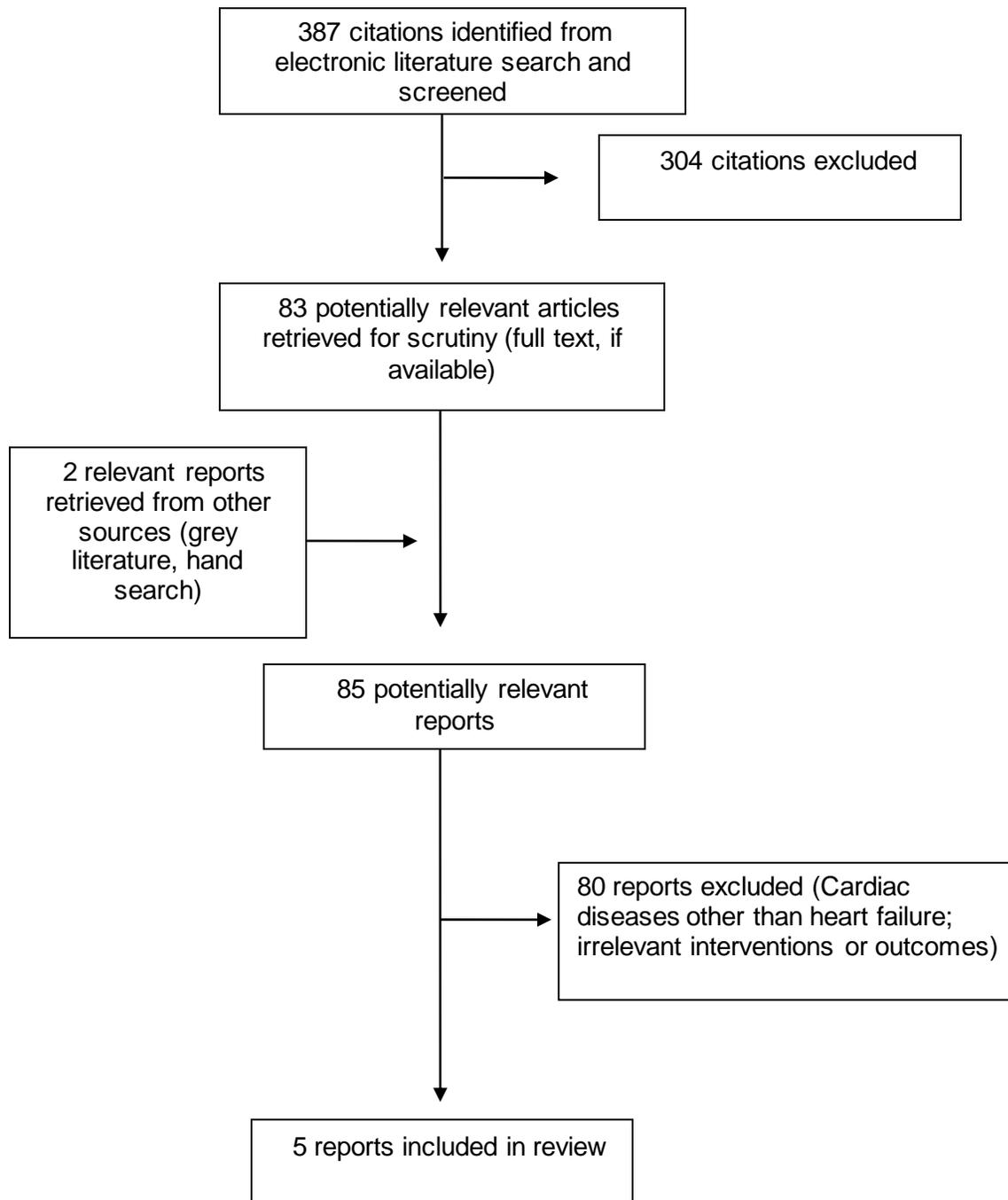
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Appendix 1: Selection of Included Studies



Appendix 2: Characteristics of Included Systematic Reviews

Table A1: Characteristics of Included Systematic Reviews				
First Author, Year, Country,	Literature Search Strategy	Inclusion Criteria	Exclusion Criteria	Studies included Main outcomes
Purcell, ⁹ 2014, Australia	This is a systematic review of systematic reviews. "A comprehensive and systematic search was undertaken using CINAHL, MEDLINE and the Cochrane Library electronic databases. Reviews were retrieved if they were published between 2000 and 2013" (p 2)	"Systematic reviews were included. ...Included reviews needed to explore the impact of telemonitoring on the health outcomes of adults with known CVD" (p 2)	"...Reviews were excluded if there was no evidence that home based measures were transmitted to a healthcare provider... reviews that were published in any language other than English" (p 2)	13 systematic reviews included (4 on hypertension or CVD; 9 on heart failure) Clinical effectiveness of telemonitoring (remote monitoring of patients using telecommunication technologies such as the Internet, telephone, or videoconferencing to transmit data) for adult patients with cardiovascular diseases or heart failure on blood pressure, all-cause and HF-related hospitalization, mortality, length of stay, health-related quality of life
Inglis, ¹⁰ 2015, UK	"We updated the searches of the Cochrane Central Register of Controlled Trials (CENTRAL), Database of Abstracts of Reviews of Effects (DARE), Health Technology Assessment Database (HTA) on the Cochrane Library;MEDLINE (OVID), EMBASE (OVID), CINAHL (EBSCO), Science Citation Index Expanded (SCI-EXPANDED), Conference Proceedings Citation Index-Science (CPCIS) on Web of Science (Thomson Reuters), AMED, Proquest Theses and Dissertations, IEEE Xplore and TROVE in January 2015. We handsearched bibliographies of relevant studies and systematic reviews and abstract conference proceedings" (p 1)	"We included only peer-reviewed, published RCTs comparing structured telephone support or non-invasive home telemonitoring to usual care of people with chronic heart failure" (p 1)	"The intervention or usual care could not include protocol-driven home visits or more intensive than usual (typically four to six weeks) clinic follow-up" (p 1) "We applied no language limits" (p 1)	43 RCTs included (25 on structured telephone support; 18 on telemonitoring) Clinical effectiveness of structured telephone support or non-invasive telemonitoring (digital/broadband/satellite/wireless/blue-tooth transmission of physiological and other non-invasive data) for adult patients with heart failure such as mortality, all-cause or heart failure-related hospitalization,

Table A1: Characteristics of Included Systematic Reviews				
First Author, Year, Country,	Literature Search Strategy	Inclusion Criteria	Exclusion Criteria	Studies included Main outcomes
				length of hospital stay, health-related quality of life, adherence
Dale, ⁹ 2015, New Zealand	<i>“A comprehensive literature search was conducted from inception through to 3 March 2015 using MEDLINE, PubMed, PsycINFO, EMBASE and The Cochrane Library”</i> (p 3)	<i>“Eligible studies used an experimental trial design to determine the effectiveness of an mHealth intervention to change lifestyle behaviours in any cardiovascular disease population”</i> (p 1)	<i>“Interventions using solely landline telephone communication were excluded”</i> (p 3) <i>“Articles published in languages other than English were excluded”</i> (p 3)	Seven studies included (3 studies on physical activity behaviour; 2 on adherence to medication; 1 on dietary habit; 1 on smoking habit) Effectiveness of mobile phones (mHealth) for patients with cardiovascular diseases on behavioural lifestyle changes (physical activity, diet, smoking, alcohol use and medication) and medication adherence

Appendix 3: Characteristics of Included Cost-effectiveness Studies

Table A2: Characteristics of Included Studies

First Author, Year, Country,	Study Objectives	Interventions/Comparators	Patients	Main outcomes
Boyne, ¹¹ 2013, The Netherlands	<i>"...The incremental cost-effectiveness of telemonitoring versus usual care in patients with congestive heart failure" (p 242)</i>	Patients with congestive heart failure randomly allocated to telemonitoring (using the telemonitoring device Health Buddy®, Sananet, Sittard, The Netherlands), or usual care.	382 patients > 18 years old with congestive heart failure levels II to IV	Cost Cost-effectiveness: incremental cost-effectiveness ratio (ICER) per quality-adjusted life years (QALYs) gained
Cui, ¹² 2013, Canada	<i>"This one-year study investigated whether the Manitoba Provincial Health Contact program for congestive heart failure (CHF) is a cost-effective intervention relative to the standard treatment" (p 37)</i>	Patients with congestive heart failure randomly allocated to standard care (group 1), standard care plus Health Lines (phone calls) interventions (group 2), or standard care plus Health Lines interventions plus in-house monitoring with monitoring devices (group 3)	179 patients ≥ 40 years old with a diagnosis of CHF levels II to IV	Costs Cost-effectiveness: ICER per QALY gained

Appendix 4: Summary of Critical Appraisal of Included Studies

Table A3: Summary of Critical Appraisal of Included Studies		
First Author, Publication Year	Strengths	Limitations
Critical appraisal of included systematic reviews (AMSTAR⁹)		
Purcell, ⁹ 2014	<ul style="list-style-type: none"> a priori design provided duplicate study selection and data extraction procedure in place comprehensive literature search performed list of included studies, study characteristics provided quality assessment of included studies provided and used in formulating conclusions conflict of interest stated 	<ul style="list-style-type: none"> list of excluded studies not provided no assessment of publication bias performed considerable heterogeneity in the interventions reported in the included studies
Inglis, ¹⁰ 2015	<ul style="list-style-type: none"> a priori design provided duplicate study selection and data extraction procedure in place comprehensive literature search performed list of included studies, study characteristics provided list of excluded studies provided quality assessment of included studies provided and used in formulating conclusions assessment of publication bias performed conflict of interest stated 	<ul style="list-style-type: none"> considerable heterogeneity in the interventions reported in the included studies
Dale, ⁹ 2015	<ul style="list-style-type: none"> a priori design provided duplicate study selection and data extraction procedure in place comprehensive literature search performed list of included studies, study characteristics provided quality assessment of included studies provided and used in formulating conclusions list of excluded studies provided conflict of interest stated 	<ul style="list-style-type: none"> no assessment of publication bias performed considerable heterogeneity in the interventions reported in the included studies
Critical appraisal of included cost studies (Drummond¹)		
Boyne, ¹¹ 2013	<ul style="list-style-type: none"> the economic evaluation is likely to be usable (a well-defined question posed in an answerable form; a comprehensive description of the competing alternatives given; evidence for the programme's effectiveness established) outcomes and costs assessed and compared appropriately (all the important and relevant outcomes and costs for each alternative identified; outcomes and costs measured accurately in appropriate units prior to evaluation; outcomes and costs valued 	<ul style="list-style-type: none"> Clinical data drawn from a relatively small sample size In some cases, medication use was gathered by prescriptions, but it is uncertain if the medication was delivered Data was imputed in a number of cases

	<p>credibly; outcomes and costs adjusted for different times at which they occurred)</p> <ul style="list-style-type: none"> • an incremental analysis of the outcomes and costs of alternatives performed • a sensitivity analysis performed • the presentation and discussion of study results include all issues of concern to users 	
<p>Cui, ¹² 2013</p>	<ul style="list-style-type: none"> • the economic evaluation is likely to be usable (a well-defined question posed in an answerable form; a comprehensive description of the competing alternatives given; evidence for the programme's effectiveness established) • outcomes and costs assessed and compared appropriately (all the important and relevant outcomes and costs for each alternative identified; outcomes and costs measured accurately in appropriate units prior to evaluation; outcomes and costs valued credibly; outcomes and costs adjusted for different times at which they occurred) • an incremental analysis of the outcomes and costs of alternatives performed • a sensitivity analysis performed • the presentation and discussion of study results include all issues of concern to users 	<ul style="list-style-type: none"> • Clinical data drawn from a relatively small sample size • Costs analyses used 2005 Canadian \$

Appendix 5: Main Study Findings and Authors' Conclusions

Table A4: Main Study Findings and Authors' Conclusions		
First Author, Publication Year	Main Study Findings	Authors' Conclusions
Research question 1 (clinical evidence regarding telehealth interventions for patients with heart failure requiring cardiac care)		
Purcell, ⁹ 2013	<p>9 reviews investigated telemonitoring in heart failure management.</p> <p>Hospital admission (8 reviews) All reviews reported that telemonitoring was associated with reduced all-cause and heart failure-related hospitalizations.</p> <p>Length of stay (5 reviews) The reviews reported conflicting findings in length of stay</p> <p>All-cause mortality (6 reviews) All reviews reported reduction in all-cause mortality</p> <p>Quality of life (6 reviews) All reviews reported improved quality of life</p>	<p><i>" Findings suggest that telemonitoring can contribute to significant reductions in blood pressure, decreased all-cause and HF related hospitalisations, reduced all-cause mortality and improved quality of life" (p 1)</i></p>
Inglis, ¹⁰ 2015	<p>Structured telephone support (25 studies) reduced all-cause mortality (RR 0.87; 95% CI 0.77 to 0.98) and heart failure-related hospitalizations (RR 0.85; 95% CI 0.77 to 0.93)</p> <p>Telemonitoring (18 studies) reduced all-cause mortality (RR 0.80; 95% CI 0.68 to 0.94) and heart failure-related hospitalizations (RR 0.71; 95% CI 0.60 to 0.83)</p> <p>All-cause hospitalizations was not reduced by either structured telephone support (16 studies) (RR 0.95; 95% CI 0.90 to 1.00) or telemonitoring (13 studies) (RR 0.95; 95% CI 0.89 to 1.01)</p> <p>Length of stay One out of seven studies on structured telephone support, and one out of nine studies on telemonitoring reported statistically significant reduction in length of hospital stay</p> <p>Health-related quality of life 9 out of 11 studies on structured telephone support, and five out of 11 studies on telemonitoring reported significant improvement in health-related QOL outcomes</p> <p>Adherence rate 55.1% to 65.8% for structured telephone support (3 studies) 75.0% to 98.5% for telemonitoring (8 studies)</p> <p>Heart failure knowledge All studies except one reported significant improvement (6 studies on structured telephone support and one study on telemonitoring)</p> <p>Self-care All studies reported significant improvement (4 studies on structured telephone support and one study on telemonitoring)</p>	<p><i>"For people with heart failure, structured telephone support and non-invasive home telemonitoring reduce the risk of all-cause mortality and heart failure-related hospitalisations; these interventions also demonstrated improvements in health-related quality of life and heart failure knowledge and self-care behaviours" (p 1)</i></p>

Table A4: Main Study Findings and Authors' Conclusions		
First Author, Publication Year	Main Study Findings	Authors' Conclusions
Dale, ⁹ 2015	Behavioural change Five out of seven studies reported a positive treatment effect (three on physical activity, two on medication adherence) No study found positive treatment effect on dietary habits, alcohol or smoking cessation	<i>“Our review found mHealth has the potential to change lifestyle behaviour. Results are still limited to a small number of trials, inconsistent outcome measures and ineffective reporting of intervention characteristics”</i> p 1)
Research question 2 (cost-effectiveness of telehealth interventions for patients with heart failure requiring cardiac care)		
Boyne, ¹¹ 2013	Health-related quality of life: no significant difference between telemonitoring group and usual care group (utility scores improved by 0.07 points for the usual care group and 0.1 points for the telemonitoring group) Costs: no significant differences in annual costs per patient between the two groups (€16,561 in the usual care group and €16,687 in the telemonitoring group) Cost-effectiveness: analysis showed high level of decision uncertainty (at a threshold of €50,000 willingness-to-pay, there is a 48% probability that telemonitoring is cost-effective; ICER for telemonitoring versus usual care: €40,321 per QALY gained)	<i>“The cost-effectiveness analysis showed a high level of decision uncertainty...It is therefore premature to draw an unambiguous conclusion regarding cost-effectiveness for the whole group”</i> (p 242)
Cui, ¹² 2013	Costs per patient including health care utilization and intervention: Usual care: Can\$7,151 Health line intervention: Can\$6,430 Health line + in-house monitoring: Can\$6,311 (differences not statistically significant) Cost-effectiveness: Health line intervention and health line intervention + in-house monitoring are more cost-effective than usual care (at the threshold of \$50,000 willingness-to-pay, there is an 85.8% probability that health line intervention is cost-effective) Health line interventions is more cost-effective than health line interventions plus in-house monitoring (ICER for health line interventions versus health line interventions plus in-house monitoring: Can\$2,975 per QALY gained)	<i>“This study provides evidence that HL is more likely to be cost-effective in the management of CHF compared to the standard and HLM interventions”</i> (p 47)
Research question 3 (evidence-based guidelines regarding telehealth interventions for patients with heart failure requiring cardiac care)		
There is no evidence found on evidence-based guideline regarding telehealth interventions for patients with heart failure or cardiovascular diseases requiring cardiac care		