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Not all systematic reviews are systematic: a meta-review of the quality of systematic reviews for non-invasive remote monitoring in heart failure

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Summary

We carried out a critical appraisal and synthesis of the systematic reviews and meta-analyses of remote monitoring for heart failure. A comprehensive literature search identified 65 relevant publications from 3333 citations. Seventeen studies fulfilled the inclusion and exclusion criteria. Seven (41%) systematic reviews pooled results for meta-analysis. Eight (47%) considered all non-invasive remote monitoring strategies. Five (29%) focused on telemonitoring. Four (24%) included both non-invasive and invasive technologies. The reviews were appraised by two independent reviewers for their quality and risk of bias using the AMSTAR tool. According to the AMSTAR criteria, ten (58%) systematic reviews were of poor methodological quality. In the high quality reviews, the relative risk of mortality in patients who received remote monitoring ranged from 0.53 to 0.88. The high quality reviews also reported that remote monitoring reduced the relative risk of all-cause (0.52 to 0.96) and heart failure-related hospitalizations (0.72 to 0.79) and, as a consequence, healthcare costs. However, further research is required before considering widespread implementation of remote monitoring. The subset of the heart failure population that derives the most benefit from intensive monitoring, the best technology, and the optimum duration of monitoring, all need to be identified.

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Introduction

The healthcare literature contains reports of hundreds of thousands of interventional studies and is growing.[1] Systematic reviews are performed to critically appraise and synthesise data from individual studies that focus on a specific clinical problem or question. In a systematic review, the methods used to identify, select and critically appraise relevant research and to collect and analyse data from the individual studies identified are explicitly stated.[2] To increase power, data collected from the individual studies included in a systematic review can be accumulated in what is known as a meta-analysis.[2] Clinical practice guidelines try to use the best available evidence to provide recommendations and a meta-analysis is accorded the highest level of evidence. However, in areas that have attracted a large amount of research, it is now common for there to be numerous systematic reviews and meta-analyses.[3,4] Therefore, there is also a need for critical appraisal and synthesis of systematic reviews and meta-analyses in order to ensure that decision-making is informed by the best available accumulated evidence. The 'meta-review', which is an overview of systematic reviews, can be used for this purpose.[2]

The aim of a meta-review is to critically appraise and synthesise findings from systematic reviews and meta-analyses. This contrasts with a systematic review, in which the intent is to critically appraise and synthesise findings from individual studies. The methodological difference between a conventional systematic review, which may or may not incorporate meta-analysis, and a meta-review, is that the latter only considers results reported in systematic reviews and meta-analyses, not results from individual studies. However, meta-reviews should utilise methods that are similar to a traditional

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systematic review. For example, in a meta-review, the methods used to review the literature, conduct quality assessment of included reviews and synthesise findings, need to be explicitly stated.[2]

Early identification of clinical deterioration in patients with heart failure by remotely monitoring for signs and symptoms of fluid accumulation or measuring fluid status can help prevent hospitalization for acute decompensated heart failure.[5] Remote monitoring interventions for heart failure can be categorized as either invasive or non-invasive. Invasive interventions involve direct measurement of physiological variables, such as heart rate and pulmonary artery pressures, by an implanted device which is then transmitted for the health care provider to access. Non-invasive interventions include telemonitoring and structured telephone support. Telemonitoring involves the transmission of physiological data, such as bodyweight, blood pressure and pulse oximetry, and other data, such as self-care practices, for the health care provider to access.[6] Structured telephone support involves direct contact between a health care provider and the heart failure patient.[6] Both invasive and non-invasive remote monitoring interventions for heart failure have been evaluated in numerous randomized controlled trials (RCTs), systematic reviews and meta-analyses. There is a need for critical appraisal and synthesis of the systematic reviews and meta-analyses. We have therefore conducted a meta-review.

Methods

We applied the principles of the Cochrane methodology to the meta-review.[2] We conducted a comprehensive literature search. The reviews identified were then analysed by summarising and comparing the population, intervention, comparison and outcomes that were reported. In addition, a quality appraisal of each review was undertaken using a validated tool.[7]

Search

The following databases were searched: CINAHL, the Cochrane Database of Systematic Reviews, the JBI library of systematic reviews, EMBASE, Health source nursing/academic edition and MEDLINE. The database searches were supplemented by manual searching of reference lists and a forward citation search was performed using Google Scholar. Only published reviews were considered. Two reviewers investigated all data sources to maximize the scope of the search, and to reduce errors and bias. Publication limits of 1996 to 2012 (inclusive) were set for all literature searches. Only articles written in full-text English were included. All potentially relevant publications were retrieved in full-text for review purposes. The search used boolean operators to combine free text terms and/or MeSH terms including heart failure, cardiac failure, telehealth, telephone, telemonitoring, impedance cardiography, remote sensing technology and disease-management. A full list of the search terms used is shown in the Appendix (see ONLINE ARCHIVE).

Study selection

Titles and abstracts were screened to eliminate articles that were clearly irrelevant. Potentially eligible publications were retrieved and the full text version was reviewed in detail. Two reviewers independently selected studies for inclusion and a third reviewer was available for arbitration. The inclusion and exclusion criteria are shown in Box 1.

Data extraction

In addition to extracting data about the characteristics of the review, such as the number of studies included, year of publication and the total number of participants, data

Box 1. Inclusion and exclusion criteria.

Inclusion criteria

Study type: Systematic review of original research. In accordance with the PRISMA statement, a systematic review was defined as a review with a clearly formulated question that used systematic and explicit methods to identify, select and critically appraise relevant research and to collect and analyse data from the studies that were included in the review.[6,35] The review had to describe a detailed search of the literature for relevant studies and synthesis of results

Publication: Full peer-reviewed publication

Population: Adult patients with a definitive diagnosis of heart failure and recently discharged from an acute care setting to home (excluding nursing homes or convalescent homes) or recruited while managed in the community setting

Intervention: Remote monitoring of patients with heart failure; initiated by a healthcare professional; delivered as the only heart failure disease management intervention, without home-visits or intensified clinic follow-up; targeted towards the patient, and not caregivers; did not include any visits at home by a specialized CHF healthcare professional or study personnel for the purpose of education or clinical

Comparison: Consisted of standard post-discharge care without intensified attendance at cardiology clinics or clinic-based CHF disease management programme or home-visits

Outcomes: All-cause mortality, CHF-related or all-cause hospitalizations, length of stay, cost of the intervention or cost reductions, quality of life, acceptability, and adherence

Exclusion criteria

Remote monitoring of conditions other than heart failure

Reviews could not include studies that involved home-visits by specialized CHF health professionals or study personnel for the purpose of education or clinical assessment or include intensified clinic follow-up

Studies were excluded if any face-to-face patient assessment was conducted as part of the intervention

about the population, intervention, comparison and outcomes were extracted. These data were extracted with a standardised tool by two reviewers, and checked by a third reviewer when uncertainties were encountered.

Quality appraisal

Reviews were appraised by two independent reviewers for their quality and risk of bias using the AMSTAR tool. This is a measurement tool, with good content validity, for the assessment of multiple systematic reviews.[7] The AMSTAR criteria also provided a standardised method to determine the extent to which the scientific quality of the studies was assessed in the systematic reviews. This criterion is an important element in the preparation of a Cochrane overview of reviews.[2] Our definition of high-quality was a review that addressed at least eight of the 11 AMSTAR criteria. We decided that setting a cut-off for the total score to indicate quality would be appropriate, as psychometric testing of the AMSTAR tool revealed that, as each component of the score measures a different domain of quality, the summary score is meaningful.[7]

Data synthesis

As many of the systematic reviews included the same studies, it was not appropriate to pool results from the individual meta-analyses.[8]

Results

Overall, 65 publications from 3333 citations were identified as being potentially relevant. Seventeen fulfilled the inclusion and exclusion criteria in Figure 1.

The average number of studies included in the reviews was 19.5 (SD = 14; range = 5–56), see Table 1. Eight reviews (47%) included only RCTs. A further eight reviews (47%) included a range of experimental, quasi-experimental and cohort designs, while one review also included findings from qualitative studies.

Systematic review quality

The quality of the reviews varied considerably, with AMSTAR scores of 2–11 (mean 5.9; SD = 2.8). Only the two reviews performed according to the Cochrane Collaboration method fulfilled all of the AMSTAR criteria.[9,10] Eight reviews (47%) did not assess the scientific quality of the included studies and only three (43%) of the systematic reviews that performed meta-analyses accounted for publication bias.

Methods used to synthesise results

Seven of the systematic reviews (41%) pooled results from individual studies for meta-analysis.[9–15] Heterogeneity of interventions was managed by the authors of one of the

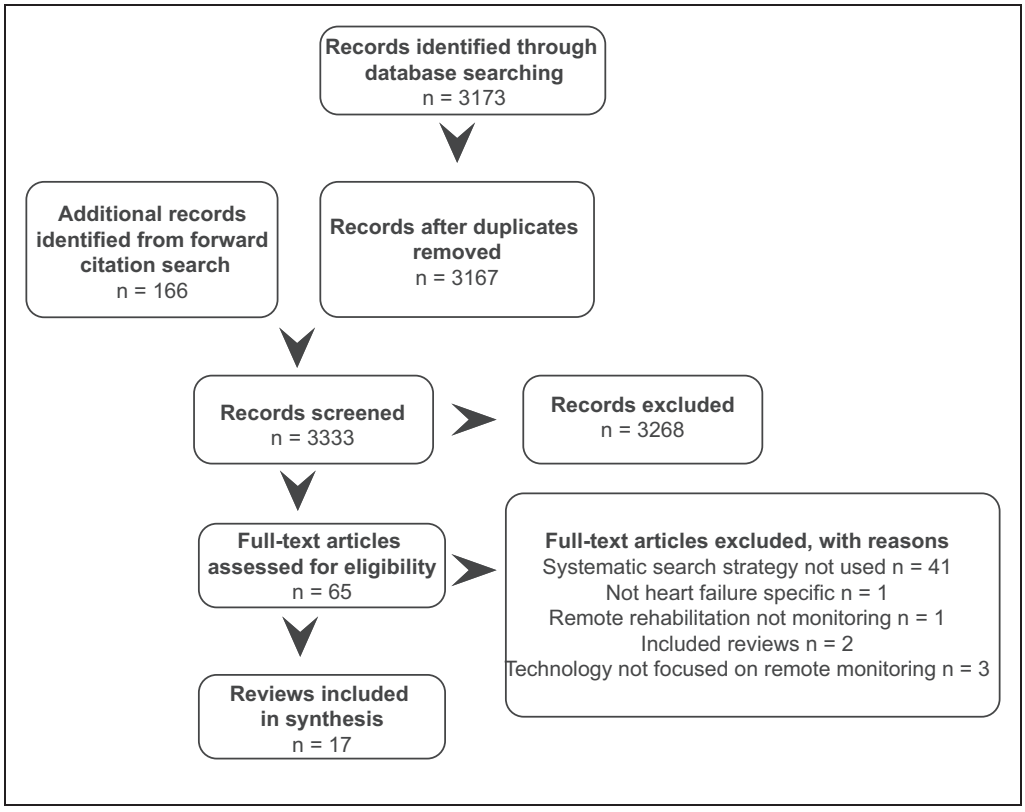

Figure 1. Search results.

Table 1. Characteristics of the reviews.

Author (year)	Number of studies	Participants	Interventions	Authors' conclusions	AMSTAR score
Systematic reviews with meta-analysis					
Clark (2007)	14 RCTs	4264	• Telemonitoring • Structured telephone support (STS)	• Reduced CHF-related admissions and all-cause mortality. • Results were mixed for QoL and costs.	11
Inglis (2010)	25 RCTs in total 16 STS 11 telemonitoring	5613 Structured Telephone Support 2710 Telemonitoring	• Telemonitoring • Structured telephone support	• STS and telemonitoring effective in reducing risk of all-cause mortality and CHF-related hospitalisations • Improves QoL, reduce costs and evidence-based prescribing.	11
Polisena (2010)	21 studies included 8 RCTs telemonitoring vs usual care 4 telemonitoring, STS, usual care 9 cohort	3082	• Telemonitoring • Structured telephone support	• Reduced mortality (6 studies) • Reduced hospitalisations (4 studies)	9
Lee (2010)	10 RCTs	2148	• Only included telephone-based post discharge nursing care	• 4 studies included in meta-analysis at 3 and 6 months follow-up • 5 studies included in meta-analysis at 12 months follow-up • Intervention decreases readmissions	8
Klersy (2011)	21 RCTs	5715	• Telemonitoring (includes data from invasive technologies) • Structured telephone support	• Remote-monitoring reduces costs compared with usual care	8
Klersy (2009)	20 RCTs 12 cohort studies	6258 in RCTs 2354 in cohort studies	• Telemonitoring (includes data from invasive technologies) • Structured telephone support	• Significant protective clinical effect • Decrease in events greater in cohort studies than RCTs	8
Clarke (2011)	13 RCTs of telemonitoring	3480	• Telemonitoring	• Reduced mortality and CHF-related hospitalisation	3
Systematic reviews without meta-analysis					
Chaudhry (2007)	9 RCTs 5-telemonitoring 1-automated 1-physiological	3582	• Telemonitoring • Structured telephone support	• Synthesis of results suggested the interventions are promising but evidence base was limited.	8
Cherofsky (2011)	3 RCTs and 2 quasi-experimental	612	• Telemonitoring • Structured telephone support	• Results equivocal • One RCT showed significant improvement in ED admissions and re-hospitalisation rates	7
Dang (2009)	5 RCTs of automated remote monitoring of signs and symptoms or physiological data (not patient-reported)	1126	• Focused on automated monitoring	• Telemonitoring a promising strategy • More research required.	5

(continued)

Table 1. Continued.

Author (year)	Number of studies	Participants	Interventions	Authors' conclusions	AMSTAR score
Louis (2003)	6 cohort 6 RCT 12 quasi-experimental designs	2629	• Includes invasive monitoring and video consultations • Telemonitoring • Structured telephone support	• Intervention promising yet adequately powered studies required.	5
Giamouzis (2012)	12 RCTs	3877	• Telemonitoring	• Studies reviewed are "in favour" of telemonitoring.	5
Kraai (2011)	14 studies 4 RCT 7 pilot 1 observational study 1 evaluation study 1 efficacy study	2005	• Non-invasive remote monitoring with external equipment to measure physiological data	• In general, patients seemed to be satisfied or very satisfied with the use of telemedicine • Measurement of patient satisfaction with telemonitoring has used poorly constructed questionnaires	5
Maric (2009)	56 studies 16 device-based 12 telephone touchpad 3 video consultations 5 website-based 21 combination (device and nurse-telephone contact)	4417 (7 studies did not specify number of participants)	• Automated physiological/symptom monitoring • Telephone touch-pad • Video consultations • Website-based modalities • Combination of telemonitoring modalities (telephone support with automated monitoring)	• Most studies showed improvement in outcomes • Some studies were small	4
Martinez (2006)	42 studies 13 RCTs 10 quasi-experimental designs 19 cohort	2303 (5 studies did not specify number of participants)	• Telemonitoring	• Technically feasible • Easy to use and accepted by patients • Economically viable • Improves outcomes	4
Radhakrishnan (2012)	14 studies 8 RCT 2 pre-post test 1 quasi- experimental designs 1 controlled pilot 1 qualitative 1 mixed-method	1452	• Telemonitoring • Video-consultation • Structured telephone support	• Focused on impact of telehealth on self-care • 5 studies improved self-care and 5 did not	3
Seto (2008)	10 studies 7 RCTs 1 quasi-experimental designs 1 cohort 1 survey	1394	• Physiological measurements only	• All studies found cost reductions mostly related to decreased hospitalisation expenditures • 3.5% lower cost in travelling for patients	2

Cochrane reviews by pooling results of interventions that were similar, namely telemonitoring and structured telephone support, separately.[10] In contrast, the meta-analyses undertaken by Klersy *et al.*[11,12] considered all remote monitoring interventions together, including even invasive monitoring strategies, and used random-effects models to account for significant statistical heterogeneity.[11,12]

Most reviews that did not use meta-analysis used a narrative approach to synthesise the findings (n = 8; 47%). The remainder (n = 2; 12%) interpreted results based on the level of evidence produced according to the type of study design that had been utilized (e.g. RCT = Level II evidence).[16,17]

Populations

The characteristics of the populations included in the reviews are summarised in Table 2. Either the mean (including SD) or range of ages of participants was reported in all of the systematic reviews. The oldest reported mean age in a study was 82 years[18] and the youngest was 45 years.[10] Similarly, the New York Heart Association (NYHA) class of participants was reported in most reviews. The majority of reviews reported that participants were NYHA class II-IV.

Other population characteristics of the studies included in the systematic reviews were not reported consistently. For example, sex distribution was summarized in only five reviews,[10–12,18,19] left ventricular ejection fraction (LVEF) reported in four, patients' medications reported in only two reviews[13,19] and a summary of comorbidities in only one systematic review.[13]

A single review reported sub-group populations within individual studies. Inglis *et al.*[10] emphasized that studies included in their systematic review provided evidence of the effectiveness of remote monitoring in Hispanic and in older people with heart failure.

Interventions and technology

Eight reviews (47%) considered all non-invasive remote monitoring strategies, including structured telephone support and automated telemonitoring.[9,15,17,18,20,21] Five reviews (29%) focused specifically on telemonitoring, which involved automated physiological and/or symptom monitoring.[13,16,22–24] Four reviews (24%) included studies investigating both non-invasive and invasive remote monitoring technologies.[11,12,25,26] One review focused specifically on remote monitoring performed by nurses.[15] None of the systematic reviews specifically focused on invasive remote monitoring.

Outcomes

Outcomes that were reported in the systematic reviews are summarized in Table 3. Death and hospitalizations were most often reported. Four reviews focused on only one specific outcome, including cost,[24,27] patient satisfaction[23] and self-care.[21] It was also common for the reviews to report on healthcare costs, compliance with monitoring and patient satisfaction with, or acceptance of, the intervention.

Mortality

Five meta-analyses identified significant improvements in all-cause mortality for remote monitoring compared with usual care,[9,10,12–14] see Figure 2. Relative risk ranged from 0.53 (95% CI = 0.29–0.96)[12] to 0.88 (95% CI = 0.76–1.01).[10] The greatest benefit was seen in a meta-analysis of cohort studies, which included both non-invasive and invasive remote monitoring.[12] Two meta-analyses suggested that the reduction in mortality with telemonitoring was more pronounced compared with structured telephone support.[10,12] In the systematic reviews that did not incorporate meta-analysis, the authors concluded either that remote monitoring was beneficial or promising because the studies included in these reviews showed reductions in mortality.

Hospitalizations

There were more modest relative risk reductions from remote monitoring for all cause compared with CHF-related hospitalizations in the meta-analyses of RCTs, see Figures 3 and Figure 4. For example, the greatest relative risk reduction of 0.72 (95% CI = 0.64–0.81) was for CHF-related hospitalization[12] compared with 0.92 (95% CI = 0.85–0.99) for all-cause hospitalization.[10]

Cost

Two of the systematic reviews examined the cost-effectiveness of remote monitoring for heart failure.[11,24] In the meta-analysis reported by Klersy *et al.*,[11] remote monitoring was found to reduce costs compared with usual care with a gain in quality-adjusted life years (QALY) of 0.06, indicating the superiority of this treatment over usual care in terms of effectiveness, cost and therefore cost-effectiveness. Another systematic review reported cost reductions associated with remote monitoring of 1.6–68.3%.[24] The cost reductions resulted from reduced hospitalizations and patient travel costs.

Self-care

One systematic review focused on the effect of remote monitoring on self-care.[21] Most studies (n = 8) included in this systematic review reported that remote monitoring improved ($P < 0.05$) self-care behaviours such as frequency of obtaining daily bodyweight, medication management, exercise adherence, and fluid and salt restriction.[28,29] However, the review identified five studies that showed no benefit to self-care from remote monitoring of heart failure.[30,31]

Table 2. Population characteristics.

Author (year)	Age (years)	Medication summary	NYHA	LVEF	Sub-populations
Systematic reviews with meta-analysis					
Clarke (2011)	Mean 55–85	Included in 6 of 13 studies	Not reported	All studies included patients <40%	Co-morbidities summarized in 6 of 13 studies
Inglis (2010)	44.5–78	Not summarised	Not summarised	Not summarised	Hispanic and elderly included. Mean 64% male (range 35-99%)
Klersy (2011)	Median 70.7 Range: 45–78	Not summarised	Reported in 18 RCTs 48% Class III–IV	Not summarised	64% male
Lee (2010)	Most studies >60	Not summarised	Not summarised	Not summarised	Not summarised
Polisena (2010)	All studies had mean age over 55	Not summarised	Most III–IV	Not summarised	Not summarised
Klersy (2009)	RCT's median 70 range 54–78 Cohort median 66 range 59–81	Not summarised	RCTs III–IV = 54% Cohort III–IV = 83%	RCTs Median 35% Range 22–43 Cohort Median 40 Range 35–44	RCTs 64% male Cohort 60% male
Clark (2007)	57–75	Not summarised	II–IV	Not summarised	Not summarised
Systematic reviews without meta-analysis					
Chaudhry (2007)	Mean 65–72	ACE (range 54–93%) and beta-locker (range 17–62%) at discharge	Majority class III–IV	Not summarised	Men range 46%–71%
Cherofsky (2011)	22–98	Not summarised	Not summarised	Not summarised	Men range 46%–71%
Dang (2009)	Means 57–63	Not summarised	Range II–IV	Not summarised	Not summarised
Giamouzis (2012)	57–58	Not summarised	II–IV	23–35%	Not summarised
Kraai (2011)	Means 50–78	Not summarised	Not summarised	Not summarised	Not summarised
Louis (2003)	Means 53–82	Not summarised	Most II–IV, one study I–III	Mean range 20–42%	Not summarised
Maric (2009)	Not summarised	Not summarised	Ranged I–IV	Not summarised	Not summarised
Martinez (2006)	48–82	Not summarised	I–IV	Not summarised	Not summarised
Radhakrishnan (2012)	Not summarised	Not summarised	Not summarised	Not summarised	Not summarised
Seto (2008)	Means 58–74	Not summarised	Not summarised	Not summarised	Males range 33%–97%

Table 3. Outcomes reported.

Study	Mortality	Hospitalisation	Cost	ED visit	QoL	Compliance	Acceptability	LoS	Clinic visits	NYHA Class	6 min walk test	Pharmacotherapy	Self care	Satisfaction	Feasibility	Impact
Systematic reviews with meta-analysis																
Clark (2007)	x	x	x		x	x	x									
Inglis (2010)	x	x				x	x			x	x	x	x			
Polisena (2010)	x	x		x	x			x	x					x		
Lee (2010)		x														
Klersy (2011)			x													
Klersy (2009)	x	x														
Clarke (2011)	x	x		x				x								
Systematic reviews without meta-analysis																
Chaudhry (2007)	x	x	x													
Cherofsky (2011)		x		x												
Dang (2009)	x	x	x	x				x	x							
Louis (2003)	x	x	x			x	x	x								
Giamouzis (2012)	x	x	x													
Kraai (2011)														x		
Maric (2009)		x		x	x			x								
Martinez (2006)															x	x
Radhakrishnan (2012)													x			
Seto (2008)			x													

ED = Emergency department; QoL = Quality of life; LoS = Length of stay in hospital; NYHA = New York Heart Association.

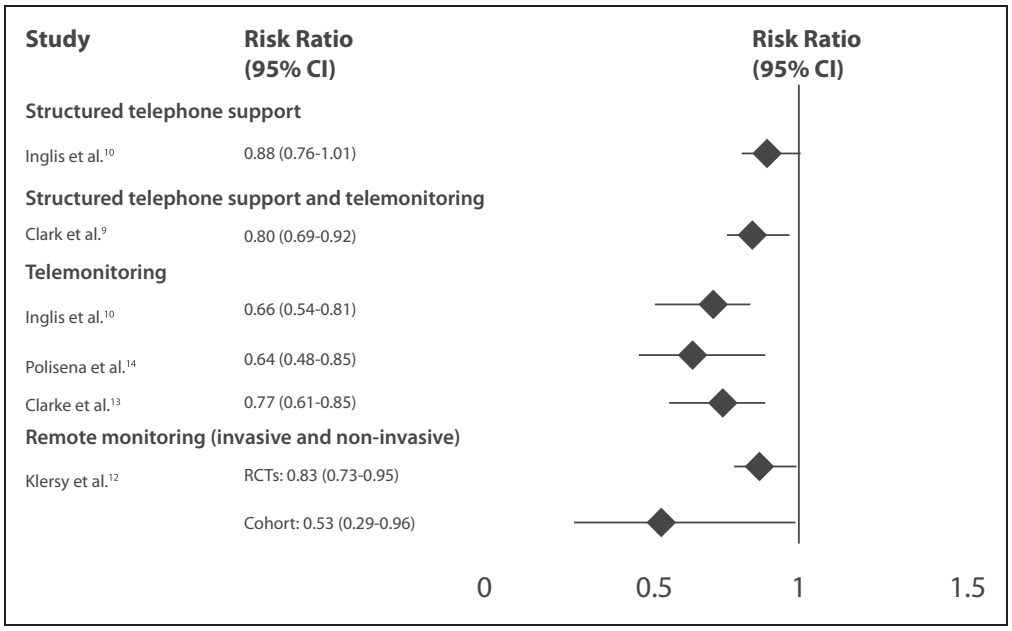

Figure 2. All-cause mortality results from meta-analyses.

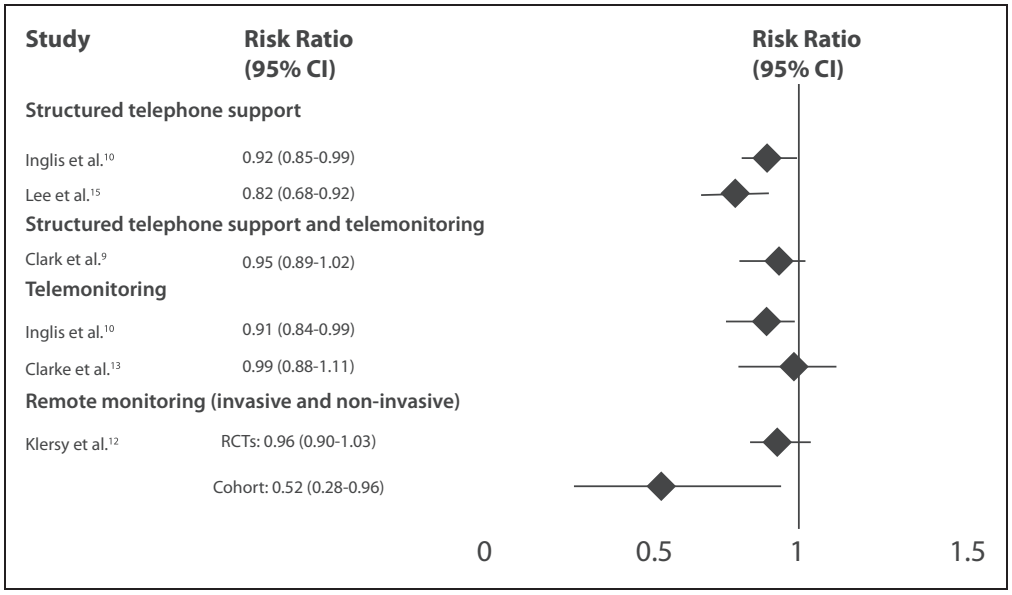

Figure 3. All-cause hospitalizations results from meta-analyses.

Quality of life

No meta-analyses of the effect of remote monitoring for heart failure on quality of life measures were identified. However, four systematic reviews reported that individual studies had identified significant ($P < 0.05$) improvements in self-reported quality of life in heart failure patients randomized to a remote monitoring intervention.[9,10,14,26]

Compliance

Compliance with the intervention was reported in five reviews, see Table 4. Compliance was generally reported to be high, ranging from 75–99%.[10,13,17,22,25]

Discussion

As far as we are aware, the present meta-review is the first to synthesise published systematic reviews of the effectiveness of remote monitoring in heart failure. Using the AMSTAR tool to appraise the quality of the systematic reviews, we were able to identify eight published systematic reviews that did not assess the scientific quality of the included studies. Two further reviews were judged to be of poor methodological quality, with total AMSTAR scores below 8.

Seven reviews did, however, conform to the majority of the AMSTAR criteria, were of high quality and can be trusted to inform policy and practice decision making.

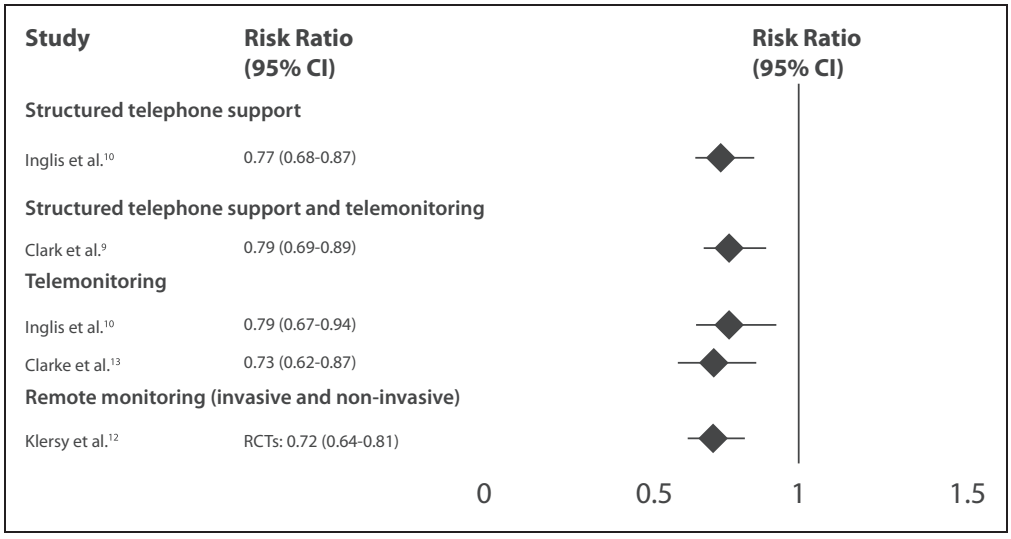

Figure 4. Chronic heart failure-related hospitalizations results from meta-analyses.

Table 4. Compliance with the intervention.

Review	Reported (Yes/No)	Results
Chaudhry (2007)	No	
Cherofsky (2011)	No	
Clark (2007)	No	
Clarke (2011)	Yes	Six studies showed high levels of compliance
Dang (2009)	No	
Giamouzis (2012)	Yes	75–98.5%
Inglis (2010)	Yes	80–97%
Klersy (2009)	No	
Klersy (2011)	No	
Kraai (2011)	No	
Lee (2010)	No	
Louis (2003)	Yes	"good acceptability ranging from 80–90%" p584
Maric (2009)	No	
Martinez (2006)	Yes	One RCT showed that 88% of the patients rated the equipment as 'very easy to use' p236
Polisena (2010)	No	
Radhakrishnan (2012)	No	
Seto (2008)	No	

These high quality reviews concluded that remote monitoring for heart failure improves mortality and quality of life as well as reduces hospitalizations and, as a consequence, healthcare costs. The reviews also suggest that remote monitoring technologies are accepted as useful by patients. Perhaps as a result, compliance was also reported to be high. Based on these positive findings, further efforts should now be directed towards optimising remote monitoring in heart failure in preparation for more widespread implementation.

A high degree of heterogeneity was reported in many of the meta-analyses included in the present review. In the most recent Cochrane meta-analysis, heterogeneity of interventions was managed by stratifying trials according to the type of technology used, namely telemonitoring or structured telephone support, with the former technique appearing superior.[10] An alternative method to overcome the problem of heterogeneity could be to use a classification scheme for remote management of heart failure.[32] This might facilitate more consistent interpretation of data by incorporating both non-invasive and invasive remote monitoring technologies. This is important because the limitations of subjective sign and symptom monitoring, as well as bodyweight-based monitoring of fluid status, indicate that invasive monitoring may be more sensitive and specific for the early detection of clinical deterioration.[33] We found no systematic review which had focused on invasive technologies for remote monitoring of heart failure.

While the mechanisms by which remote monitoring improves mortality and reduces the risk of hospitalizations for acute decompensated heart failure remains uncertain, the results of our meta-review provide some insight. As might be expected, remote monitoring is more effective in reducing CHF-related hospitalizations than all-cause hospitalizations. Although it has been proposed that better self-care improves early detection and intervention, we could not find substantial support for this hypothesis.[21] Further research is required to elucidate why patients with heart failure generally experience better clinical outcomes when remote monitoring technologies are used.

Anker *et al*. noted in their recent discussion paper that a problem with meta-analyses of remote monitoring in heart failure is that the trials which were included enrolled patients who varied in clinical status, stability and degree of previous treatment.[32] We also found that no specific determination of the effect of remote monitoring in a subset of heart failure patients could be derived from the systematic reviews. Standardized reporting of population characteristics in future research would be helpful.

The results of the higher quality meta-analyses included in the present meta-review are in contrast with two recent RCTs of remote monitoring for heart failure, neither of which demonstrated an improvement in outcomes compared with usual care.[19,27] Data from these trials will need to be incorporated into an updated meta-analysis. However, two conclusions can be drawn from their results. One trial (Tele-HF) used a voice-interactive system that appears to have been disliked by many patients, since 14% of intervention patients did not use the technology at all and only 55% used the technology at least three times per week. In contrast, compliance was reported to be 75-99% in the high quality meta-analyses.[10,25] No per-protocol analysis has been reported to investigate whether the poor compliance affected the results.

In the other trial (TIM-HF), the patients enrolled demonstrated little variance in treatment, probably because they were medically stable at the time of enrolment.[27] Sub-group analyses showed that the participants who were hospitalized due to exacerbation of heart failure prior to randomization derived the most benefit from the intervention.[34] Thus, this trial provides evidence that it is not the remote monitoring that produces improved clinical outcomes but some kind of interaction involving the patient and the health care provider. The complexity of this interaction is not yet fully understood.

To our knowledge, only one other meta-review in telemedicine has used the AMSTAR instrument to appraise the quality of systematic reviews.[35] We consider that this tool is appropriate, as it has good content validity and it has been used previously to appraise the quality of meta-analyses in heart failure disease management programmes.[7,36]

It should be noted that only English language reviews were included in the present study. We considered this to be acceptable because English language reviews represent a robust view of the available evidence base in health areas.[37]

In conclusion, our meta-review provides important information for policy and practice decision-makers regarding remote monitoring interventions for the management of patients with heart failure. By using the AMSTAR tool for quality appraisal, we identified systematic reviews of high quality, which can be trusted to inform decision-making. These high quality reviews suggest that decision makers can expect the following benefits from remote monitoring of patients with heart failure: (1) reductions in all-cause and heart failure-related hospitalizations; (2) reductions in all-cause mortality; (3) reductions in healthcare costs; and (4) improved quality of life. However, further research is required before widespread implementation can be considered. The subset of the heart failure population that derives the most benefit from intensive monitoring, the particular type or combination of technology that provides the best collection, transmission and interpretation of data, and the optimum duration that patients should be monitored, all need to be identified.

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