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Hospital-based quality improvement interventions for patients with heart failure: a systematic review

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Abstract

Objective—To estimate the direction and magnitude of effect and quality of evidence for hospital-based heart failure (HF) quality improvement interventions on process of care measures and clinical outcomes among patients with acute HF.

Review methods—We performed a structured search to identify relevant randomised trials evaluating the effect of in-hospital quality improvement interventions for patients hospitalised with

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Contributors AA, EB, MAB, AFH, DP and MDH conceived and designed the study. MAB did the scientific literature search. AA, EB, SGKY and MDH screened abstracts and full texts. AA, SGKY and MDH performed data extraction, risk of bias and graded the quality of evidence. All authors contributed to the data analysis and critically revised the manuscript. AA is the study guarantor.

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HF through February 2017. Studies were independently reviewed in duplicate for key characteristics, outcomes were summarised and a qualitative synthesis was performed due to substantial heterogeneity.

Results—From 3615 records, 14 randomised controlled trials were identified for inclusion with multifaceted interventions. There was a trend towards higher in-hospital use of ACE inhibitors (ACE-I; 57.9% vs 40.0%) and beta-blockers (BBs; 46.7% vs 10.2%) in the intervention than the comparator in one trial (n=429 participants). Five trials (n=78 727 participants) demonstrated no effect of the intervention on use of ACE-I or angiotensin receptor blocker at discharge. Three trials (n=89 660 participants) reported no effect on use of BB at discharge. Two trials (n=419 participants) demonstrated a trend towards lower hospital readmission up to 90 days after discharge. There was no consistent effect of the quality improvement intervention on 30-day all-cause mortality, hospital length of stay and patient-level health-related quality of life.

Conclusions—Randomised trials of hospital-based HF quality improvement interventions do not show a consistent effect on most process of care measures and clinical outcomes. The overall quality of evidence for the prespecified primary and key secondary outcomes was very low to moderate, suggesting that future research will likely influence these estimates.

Trial registration number—CRD42016049545.

INTRODUCTION

Heart failure (HF) is an end-stage manifestation of cardiovascular disease and a growing cause of global cardiovascular morbidity and mortality.¹² HF affects an estimated 26 million people world-wide and is estimated to have cost ~108 billion globally in 2012.³ At 40 years of age, the lifetime risk of developing HF is one in four in the USA and even higher in some race/ethnic subgroups.⁴ The prevalence of HF in the USA is expected to increase 46% from 2012 to 2030 leading to greater than 8 million patients with HF and approximately 50% of patients diagnosed with HF will die within 5 years.⁵⁶

Given the high mortality and morbidity rates of patients with HF and disparities in the use of guideline-recommended therapy,⁷⁸ quality improvement initiatives have been developed to improve clinical outcomes. These quality improvement initiatives have largely targeted inpatient HF management such as the American Heart Association's Get With the Guidelines programme, which has been associated with improvements in processes of care and lower 30-day readmission rates.⁹ Large-scale, hospital-based registries with associated quality improvement tools, such as the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF) and the Acute Decompensated Heart Failure National Registry (ADHERE), have also demonstrated the use of inpatient process-of-care improvement tools are associated with better quality of care as defined by use of guideline-recommended therapy, adherence to performance measures and shorter length of hospitalisation.⁷¹⁰ However, whether these relationships are causal or are driven by patient-level, provider-level or institutional-level confounders is less certain but appears possible.

To understand which components of these multifaceted quality improvement interventions are effective, several research teams have led randomised trials evaluating the effect of HF

quality improvement interventions to overcome the potential confounding and bias inherent in non-randomised studies. Most hospital-based quality improvement interventions include admission and discharge checklists, personalised site performance feedback and patient education.¹¹ These interventions may be particularly useful in low-income and middle-income countries (LMICs) where the quality of HF care remains poor,¹² and adherence to guideline-recommended therapy is suboptimal.¹³ The objective of this systematic review is to estimate the direction and magnitude of effect and quality of evidence for randomised trials of hospital-based HF quality improvement interventions on process of care measures and clinical outcomes among patients with acute HF.

METHODS

Literature search and study selection

This review evaluated the effect of in-hospital heart failure quality improvement interventions in hospitalised patients with heart failure compared with usual care on the primary outcomes of in-hospital mortality, in-hospital and discharge medical therapy and hospital readmissions up to 90 days after discharge (online appendix 1). We followed guidelines published by the Cochrane Collaboration to synthesise the effects of multiple interventions,¹⁴ and the prespecified protocol was prospectively registered.¹⁵

We searched multiple bibliometric databases for published literature from date of inception to 6 February 2017. We also searched [ClinicalTrials.gov](https://clinicaltrials.gov) for records of ongoing trials and unpublished studies on 13 February 2017. An experienced information specialist (MAB) performed all searches. We contacted study authors of included trials when necessary to identify additional information we might have missed. We used the reference section of published trials that met our inclusion criteria as an added resource to identify other trials. Details of the search methods are provided in online appendix 2.

Eligibility criteria

We included randomised trials of HF quality improvement interventions. We sought to include quasi-randomised (eg, interrupted time series), but there were none identified in our search. We excluded general, hospital-based quality improvement interventions. We included trials that tested the effect of a variety of individual or combined interventions including but not limited to: audit and feedback reporting systems, admission and discharge checklists, chart case management, patient educational or behavioural change materials, healthcare quality training that was directed at the hospital system, doctors, nurses or allied health professionals or information management systems with the goal of being inclusive in the type and target of intervention. We included trials evaluating the effect of these interventions among individuals admitted to hospitals for the management of acute HF.

Data extraction

Three authors (AA, EB and SGKY) independently screened abstracts, titles and full texts of retrieved studies in duplicate to identify studies to be assessed further. Two authors (AA and SGKY) independently extracted key data using a structured data extraction form and assessed risk of bias using the Cochrane Risk of Bias Tool. Discrepancies in risk of bias

assessment were resolved through consensus or through review with a third review author (MDH).

Outcomes

We included a combination of process of care measures and clinical outcomes. The primary outcomes included: (1) rate of in-hospital mortality, (2) rates of in-hospital and discharge medical therapy and (3) rate of hospital readmission up to 90 days after discharge. The secondary outcomes included: (1) rates of 30-day and 90 day all-cause mortality, (2) hospital length of stay, (3) uptake of quality improvement intervention components, (4) rate of cardiac rehabilitation referral, (5) rate of implantable cardioverter defibrillator (ICD) placement to prevent sudden death in eligible patients, (6) patient-level health-related quality of life using a validated instrument and (7) patient-related direct costs. We created a summary of findings table reporting the effects of the intervention and the quality of evidence related to the primary and key secondary outcomes.

Quality assessment

Two authors (AA, SGKY) independently evaluated the quality of evidence using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework, which takes into account issues related to internal validity and external validity.¹⁶ Discrepancies were resolved through consensus or through review with a third review author (MDH).

Data synthesis

We planned to perform a meta-analysis, but there was substantial, unexplained heterogeneity across the studies, as well as differences in their presentation of intervention effects that precluded pooling and reporting of summary effect estimates. Thus, we present a narrative, qualitative synthesis.

RESULTS

Search results

The initial search identified 3615 records after merging data from independent searches and removing duplicates (figure 1). After title and abstract screening, we evaluated 69 full-text articles and identified 14 studies for inclusion in the review.^{1117–29} Details regarding studies that were excluded are reported in online appendix 3, and details regarding ongoing studies are reported in online appendix 4.

Characteristics of the included studies

A description of the 14 included studies is provided in online appendix 5, and detailed characteristics of the included studies are provided in online appendix 6. We identified six cluster randomised control trials (cRCTs) in which the unit of randomisation was the hospital^{111824–2629} and eight RCTs in which the unit of randomisation was the individual.^{1719–232728} Eight studies were conducted in a single academic centre.^{1719–232728} Ten studies were conducted in the USA,^{1118–2022–2426–28} and four studies were conducted in Sweden,¹⁷

Japan,²¹ Italy²⁵ and Canada.²⁹ Two cRCTs contributed the greatest number of participants (DeVore *et al.*: 71 829 participants¹¹; Tu *et al.*: 17 544 participants²⁹), and three RCTs included <200 participants.¹⁷²¹²⁸ Participants were hospitalised patients with HF, and type or cause of HF was generally not reported. Two studies also included outpatients with HF, and disaggregated data specifically for hospitalised patients with HF were not available.¹⁹²⁰ Participants' mean age ranged from 63.0 to 80.7 years, and the proportion of females in each study ranged from 1% to 63%. Two trials did not report age nor sex.¹⁸²⁴

Trial-specific risk of bias assessment is presented in figure 2, and detailed risk of bias assessment is presented in online appendix 6. Thirteen trials had low risk of selection bias based on reported methods of random sequence generation,^{111719–29} but only four trials had low risk of selection bias based on reported methods of allocation concealment.¹⁹²⁰²²²⁷ All others had an unclear risk of selection bias based on reported methods of allocation concealment.^{1117182123–262829} Most trials (n=12) did not blind study personnel nor participants given the nature of the quality improvement intervention and were at high risk of performance bias.^{11171821–29} One trial had high risk of detection bias from lack of blinding of outcome assessors,²³ four trials had low risk of detection bias¹⁷¹⁸²⁰²⁸ and the remainder had an unclear risk of detection bias from reported methods of outcome assessment.^{1119212224–2729} Five trials had high risk of attrition bias from incomplete outcome data.^{19–212324} Two trials had high risk of reporting bias from selective reporting based on previously published protocols,²⁰²⁹ 2 trials had low risk of reporting bias¹¹²⁵ and 10 trials had unclear risk of reporting bias.^{17–1921–2426–28}

Interventions

In-hospital HF quality improvement interventions varied considerably across trials. Five trials tested multifaceted quality improvement interventions that included various combinations of HF specific patient education, HF guideline clinical staff education, admission order sets, in-hospital guideline-recommended medication reminders, discharge checklists, case management coordination of care, performance reports and postdischarge telephone calls.^{1823–26} Interventions in five trials emphasised HF specific patient education on medication management including self-management of diuretics, maintaining a symptom diary, diet and tobacco and alcohol cessation.¹⁷²¹²²²⁷²⁸ Two large cRCTs evaluated the specific effect of audit and feedback by sharing personalised quality improvement reports highlighting performance measures to each hospital site¹¹ or via a publicly released report card.²⁹ Two studies evaluated the effect of automated guideline-recommended medication reminders attached to echocardiography reports.¹⁹²⁰

Primary outcomes

Primary outcomes included rate of in-hospital mortality, rates of in-hospital and discharge medical therapy and rate of hospital readmission up to 90 days after discharge (table 1). Overall, mean rates of in-hospital mortality presented in three trials (n=75 164 participants) ranged from 3.4% to 5.6% in the intervention group compared with 3.4% to 15.4% in the comparator group.¹¹²⁵²⁶ Two trials revealed no effect of the quality improvement intervention on in-hospital mortality. The smallest of the three trials reporting in-hospital mortality demonstrated a decrease from 15.4% (33 events/215 participants) in the

comparator group to 5.6% (12 events/214 participants) in the intervention group.²⁵ One trial (n=429 participants) measured rates of in-hospital medical therapy. In-hospital use of ACE inhibitors (ACE-Is) increased from 40.0% in the comparator group to 57.9% in the intervention group, and in-hospital use of beta-blockers (BBs) increased from 10.2% in the comparator group to 46.7% in the intervention group.²⁵ Six trials (n=96 271 participants) measured rates of discharge medical therapy.¹¹¹⁸²³²⁵²⁶²⁹ Five out of six trials demonstrated no effect of the quality improvement intervention on use of ACE-I or angiotensin receptor blocker (ARB) at discharge. In the largest cRCT (n=71 829 participants), the estimated treatment effect (95% CI) of the intervention on ACE-I or ARB at discharge was 0.8% (95% CI -2.7% to 4.2%; p=0.67) between the intervention and control groups.¹¹ The second largest cRCT (n=17 544 participants) revealed the absolute difference (95% CI) for intervention versus control on ACE-I or ARB at discharge for participants with left ventricular systolic dysfunction was 5.9% (95% CI 1.0% to 10.7%; p=0.02) higher in the intervention group.²⁹ Three trials reported no effect of the quality improvement intervention on use of BB at discharge,¹¹²³²⁹ and one trial reported no effect of the intervention on use of aldosterone antagonist at discharge.¹¹ Of the three small trials reporting hospital readmissions up to 90 days after discharge (n=706 participants), two demonstrated an effect of the intervention on reducing hospital readmissions from 67% and 19% in the comparator to 37% and 7%, respectively.²³²⁷²⁸

Secondary outcomes

Secondary outcomes included rates of 30-day and 90-day all-cause mortality, hospital length of stay, uptake of quality improvement intervention components, rate of cardiac rehabilitation referral, rate of ICD placement to prevent sudden death in eligible patients, patient-level health-related quality of life using a validated instrument and patient-related direct costs (table 1). Prespecified outcomes that were not reported by any of the included trials include: uptake of quality improvement intervention components, rate of cardiac rehabilitation referral, rate of ICD placement to prevent sudden death in eligible patients and patient-related direct costs. Two studies (n=17 681 participants) demonstrated no effect of the quality improvement intervention on 30-day all-cause mortality with the outcome ranging from 7.5% to 10.6% in the comparator to 7.1% to 9.6% in the intervention, respectively (p=1.00, p=0.26).²⁸²⁹ Between two studies reporting hospital length of stay (n=3335 participants), the smaller trial showed a decrease in the mean (95% CI) hospital length of stay by 1 day in the intervention group from 11.4 (95% CI 10.5 to 12.3) days to 10.4 (95% CI 9.6 to 11.0; p=0.03) days in the comparator group.²⁵²⁶ Three trials (n=3411 participants) assessed patient-level health-related quality of life using validated questionnaires.²²²⁶²⁷ Only one trial demonstrated an improvement in patient-level health-related quality of life as assessed by the Chronic Heart Failure Questionnaire with mean (SD) score improving from 11.3 (16.4) in the comparator to 22.1 (20.8) in the intervention,²⁷ but the other two trials demonstrated no difference.

Study quality assessment

Outcome-specific assessment of the quality of included studies using the GRADE framework is presented in table 2. The quality of evidence for the primary outcomes of in-hospital mortality and in-hospital medical therapy was low, and both outcomes were

downgraded for inconsistency and imprecision.¹⁶ The quality of evidence for the primary outcome of discharge medical therapy was moderate, downgraded for inconsistency as the direction of effect was inconsistent and point estimates varied across studies. The quality of evidence was low for the secondary outcome of hospital readmission up to 90 days after discharge, downgraded for inconsistency and imprecision. The quality of evidence was low for the secondary outcomes of 30 day all-cause mortality and hospital length of stay. For the secondary outcome of patient-level health-related quality of life, the quality of evidence was very low, downgraded for inconsistency, imprecision, and study limitations.

DISCUSSION

Randomised trials of hospital-based HF quality improvement interventions do not show a consistent effect on process of care measures nor clinical outcomes including in-hospital mortality, discharge medical therapy, 30-day all-cause mortality, hospital length of stay and patient-level health-related quality of life. These interventions appear to increase utilisation of in-hospital ACE-I and BB and may reduce hospital admission up to 90 days after discharge. To our knowledge, this is the first systematic review of randomised trials to evaluate the effect of in-hospital HF quality improvement interventions compared with usual care on a range of outcomes of importance in hospitalised patients with HF.

The varied interventions studied in these RCTs have more modest effects on process of care measures than non-randomised studies suggest. During the 2-year OPTIMIZE-HF observational quality improvement registry with 259 participating US hospitals, the prescription rates of BB at discharge increased from 76.3% to 86.4% ($p<0.001$).¹⁰ However, in an cRCT of 147 hospitals participating in the Get With The Guidelines – Heart Failure quality improvement programme, there was no change in the already high rates of BB at discharge (96.8% in the intervention group vs 95.5% in the comparator group; estimated treatment effect: 1.05, 95% CI –1.17 to 3.27, $p=0.36$) as a result of personalised performance feedback.¹¹ Furthermore, median rates of use of ACE-I in participants with left ventricular systolic dysfunction in the ADHERE registry were 72.0%, revealing a gap in adherence to established quality-of-care indicators during the period of data collection (July 2002 to December 2003).⁷ However, both subsequent observational HF registry and RCT data demonstrate little effect of quality improvement interventions on treatment rates of ACE-I or ARB at discharge for eligible participants,¹⁰¹¹¹⁸²³²⁵²⁶ which may be driven by favourable temporal trends in medication use in the comparator groups.

It can be challenging to assess which elements of multicomponent interventions, including audit and feedback on performance metrics, standardised HF checklists for admission and discharge, clinical pathways and patient education, influence heterogeneous process of care measures and clinical outcomes. Two large cRCTs demonstrated no effect of release of performance indicators either via personalised feedback to the hospital or publicly released report cards on quality of care measures.¹¹²⁹ The trials did not report process changes at the hospital level implemented as a result of the performance feedback; hence, there may be substantial heterogeneity across hospitals in their local quality improvement activities. The trials that focused primarily on patient education were small in size ($n=38$ to 282

participants) and may have been underpowered to demonstrate a potential effect on measured outcomes.¹⁷²¹²²²⁷²⁸

Notably, there were no RCTs evaluating in-hospital HF quality improvement interventions from LMICs. The overall baseline quality of care in the USA, Sweden, Japan and Italy at the time of these trials may have been too high to demonstrate a significant effect of these interventions because of background improvements in the quality and safety of in-hospital HF care. Countries with lower quality of HF care including lower baseline use of guideline-recommended therapy may have a greater opportunity to benefit from in-hospital HF quality improvement interventions. For example, in contrast to baseline rates of ACE-I or ARB at discharge in ADHERE (72.5%), OPTIMIZE-HF (84% in first quarter) and GWTG-HF (93.9% in control), the Trivandrum Heart Failure Registry in India revealed lower rates of participants with left ventricular systolic dysfunction prescribed ACE-I at discharge (41.0%).⁷¹⁰¹¹¹³ The Acute Coronary Syndrome Quality Improvement in Kerala (ACS QUIK) cluster randomised, stepped wedge trial evaluated the effect of an in-hospital quality improvement toolkit for participants with acute myocardial infarction in India and demonstrated modestly higher rates of discharge medical therapy among the intervention group. This suggests potential gains in process of care measures with hospital-based HF quality improvement interventions may be possible in this setting.³⁰ Whether such gains would translate into improvements in clinical outcomes, which were not observed in ACS QUIK, remains uncertain.

This systematic review has several strengths. First, this review includes only RCTs to better examine the potential effect of quality improvement interventions. Second, the prespecified published protocol prior to initiation of the systematic review guided the search strategy and evidence synthesis to minimise the risk of bias in the review process.¹⁵ Third, title screening, data extraction and quality assessments were performed in duplicate to minimise error or bias in the review process.

This review also has important limitations. First, HF type was not consistently reported across studies, and hence, we have limited ability to comment on the effect of the interventions in patients with HF with preserved ejection fraction versus HF with reduced ejection fraction. Second, there is substantial heterogeneity in the types of in-hospital quality improvement interventions included in this review. Third, pooling of summary estimates was not performed due to substantial and unexplained heterogeneity across the studies. We did not include non-randomised studies during which time there have been temporal improvements in process of care measures and clinical outcomes; however, randomised studies are better suited to assess the causal relationships between complex interventions and outcomes.

CONCLUSION

This systematic review demonstrates that randomised trials of in-hospital quality improvement interventions do not have a consistent effect on process of care measures and clinical outcomes in hospitalised participants with HF. The overall quality of evidence for the prespecified primary and key secondary outcomes was very low to moderate, suggesting

that future research will likely influence these estimates. This review demonstrates the gaps in the evidence base for in-hospital quality improvement interventions for acute HF and suggests future areas of inquiry including the need for trials in LMIC settings where baseline quality of care may be lower.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. Yancy CW, Jessup M, Bozkurt B, et al. ACCF/AHA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology* 2013;62:147–239.
2. Roth GA, Huffman MD, Moran AE, et al. Global and regional patterns in cardiovascular mortality from 1990 to 2013. *Circulation* 2015;132:1667–78. [PubMed: 26503749]
3. Cook C, Cole G, Asaria P, et al. The annual global economic burden of heart failure. *Int J Cardiol* 2014;171:368–76. [PubMed: 24398230]
4. Huffman MD, Berry JD, Ning H, et al. Lifetime Risk for Heart Failure Among White and Black Americans. *J Am Coll Cardiol* 2013;61:1510–7. [PubMed: 23500287]
5. Heidenreich PA, Albert NM, Allen LA, et al. Forecasting the impact of heart failure in the United States: a policy statement from the American Heart Association. *Circ Heart Fail* 2013;6:606–19. [PubMed: 23616602]
6. Mozaffarian D, Benjamin EJ, As G, et al. Heart disease and stroke statistics—2016 update. *Circulation* 2016;133:e38–60. [PubMed: 26673558]
7. Fonarow GC. Adherence to heart failure quality-of-care indicators in US hospitals. *Arch Intern Med* 2005;165:1469. [PubMed: 16009861]
8. Fonarow GC, Peterson ED. Heart failure performance measures and outcomes. *JAMA* 2009;302:792. [PubMed: 19690314]
9. Heidenreich PA, Hernandez AF, Yancy CW, et al. Get with the guidelines program participation, process of care, and outcome for medicare patients hospitalized with heart failure. *Circ Cardiovasc Qual Outcomes* 2012;5:37–43. [PubMed: 22235067]
10. Fonarow GC. Influence of a performance-improvement initiative on quality of care for patients hospitalized with heart failure. *Arch Intern Med* 2007;167:1493. [PubMed: 17646603]
11. DeVore AD, Cox M, Heidenreich PA, et al. Cluster-randomized trial of personalized site performance feedback in get with the guidelines-heart failure. *Circ Cardiovasc Qual Outcomes* 2015;8:421–7. [PubMed: 26175533]
12. Callender T, Woodward M, Roth G, et al. Heart failure care in low- and middle-income countries: a systematic review and meta-analysis. *PLoS Med* 2014;11:e1001699. [PubMed: 25117081]
13. Harikrishnan S, Sanjay G, Anees T, et al. Clinical presentation, management, in-hospital and 90-day outcomes of heart failure patients in Trivandrum, Kerala, India: the Trivandrum Heart Failure Registry. *Eur J Heart Fail* 2015;17:794–800. [PubMed: 26011246]

14. Higgins JPT. Cochrane Handbook for Systematic Review of Interventions. 5th edn: The Cochrane Collaboration, 2018.
15. PROSPERO International Prospective Register of Systematic Reviews. Hospital-based quality improvement interventions for patients with heart failure: a systematic review. CRD42016049545 http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD4201604954 (Accessed 13 Mar 2018).
16. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;336:924–6. [PubMed: 18436948]
17. Cline CM, Israelsson BY, Willenheimer RB, et al. Cost effective management programme for heart failure reduces hospitalisation. *Heart* 1998;80:442–6. [PubMed: 9930041]
18. Hayes RP, Baker DW, Luthi JC, et al. The effect of external feedback on the management of medicare inpatients with congestive heart failure. *Am J Med Qual* 2002;17:225–35. [PubMed: 12487338]
19. Heidenreich PA, Chacko M, Goldstein MK, et al. ACE inhibitor reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction. *Am J Med* 2005;118:1034–7. [PubMed: 16164891]
20. Heidenreich PA, Gholami P, Sahay A, et al. Clinical reminders attached to echocardiography reports of patients with reduced left ventricular ejection fraction increase use of beta-blockers: a randomized trial. *Circulation* 2007;115:2829–34. [PubMed: 17515459]
21. Kato NP, Kinugawa K, Sano M, et al. How effective is an in-hospital heart failure self-care program in a Japanese setting? Lessons from a randomized controlled pilot study. *Patient Prefer Adherence* 2016;10:171–81. [PubMed: 26937177]
22. Koelling TM, Johnson ML, Cody RJ, et al. Discharge education improves clinical outcomes in patients with chronic heart failure. *Circulation* 2005;111:179–85. [PubMed: 15642765]
23. Laramee AS, Levinsky SK, Sargent J, et al. Case Management in a Heterogeneous Congestive Heart Failure Population. *Arch Intern Med* 2003;163:809. [PubMed: 12695272]
24. Newhouse RP, Dennison Himmelfarb C, Morlock L, et al. A phased cluster-randomized trial of rural hospitals testing a quality collaborative to improve heart failure care: organizational context matters. *Med Care* 2013;51:396–403. [PubMed: 23579349]
25. Panella M, Marchisio S, Demarchi ML, et al. Reduced in-hospital mortality for heart failure with clinical pathways: the results of a cluster randomised controlled trial. *Qual Saf Health Care* 2009;18:369–73. [PubMed: 19812099]
26. Philbin EF, Rocco TA, Lindenmuth NW, et al. The results of a randomized trial of a quality improvement intervention in the care of patients with heart failure. The MISCHF Study Investigators. *Am J Med* 2000;109:443–9. [PubMed: 11042232]
27. Rich MW, Beckham V, Wittenberg C, et al. A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. *N Engl J Med* 1995;333:1190–5. [PubMed: 7565975]
28. Sales VL, Ashraf MS, Lella LK, et al. Utilization of trained volunteers decreases 30-day readmissions for heart failure. *J Card Fail* 2013;19:842–50. [PubMed: 24331204]
29. Jv T, Donovan LR, Lee DS, et al. Effectiveness of Public Report Cards for Improving the Quality of Cardiac Care. *JAMA* 2009;302:2330. [PubMed: 19923205]
30. Huffman MD, Mohanan PP, Devarajan R, et al. Effect of a Quality Improvement Intervention on Clinical Outcomes in Patients in India With Acute Myocardial Infarction: The ACS QUIK Randomized Clinical Trial. *JAMA* 2018;319:567. [PubMed: 29450524]

Figure 1. PRISMA flow chart of included studies. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Cline 1998	+	?	-	+	+	?	?
DeVore 2015	+	?	-	?	?	+	?
Hayes 2002	?	?	-	+	?	?	?
Heidenreich 2005	+	+	+	?	-	?	?
Heidenreich 2007	+	+	+	+	-	-	?
Kato 2016	+	?	-	?	-	?	-
Koelling 2005	+	+	-	?	+	?	?
Laramie 2003	+	?	-	-	-	?	?
Newhouse 2013	+	?	-	?	-	?	?
Panella 2009	+	?	-	?	?	+	?
Philbin 2000	+	?	-	?	+	?	?
Rich 1995	+	+	-	?	+	?	?
Sales 2013	+	?	-	+	+	?	?
Tu 2009	+	?	-	?	+	-	?

Figure 2.
Risk of bias assessment of included studies.

Summary of outcomes from included studies

Table 1

Outcome	Trial	Intervention	Comparator	Significance
In-hospital mortality	DeVore 2015: n=165 hospitals randomised, 71 829 participants analysed.	Baseline mean (SE): 2.9% (0.26); postintervention absolute change mean (SE): 0.49% (0.44).	Baseline mean (SE): 2.9% (0.28). Postintervention absolute change mean (SE): 0.48% (0.34).	Estimated treatment effect (95% CI): -0.03 (95% CI -1.12 to 1.05); p=0.96.
	Panella 2009: n=14 hospitals, 429 participants analysed.	No: 12/214, 5.6% (95% CI 2.5% to 8.7%).	No: 33/215, 15.4% (95% CI 10.5% to 20.2%).	P=0.001.
In-hospital medical therapy	Philbin 2000: n=10 hospitals, 2906 participants analysed.	Baseline mean: 5.9%. Postintervention mean: 5.2%.	Baseline mean: 5.4%. Postintervention mean: 3.7%.	Intervention effect (95% CI): 1.0% (-95% CI -3.0% to 5.0%); p=0.57.
	Panella 2009: n=14 hospitals, 429 participants analysed.	ACE-I %: 57.9%. BB %: 46.7%. Diuretics %: 95.3%.	ACE-I %: 40.0%. BB %: 10.2%. Diuretics %: 95.8%.	P<0.001. P<0.001. P=0.8.
Discharge medical therapy	DeVore 2015: n=165 hospitals randomised, 71 829 participants analysed.	Baseline mean (SE): ACE-I/ARB %: 92.8% (1.02). BB %: 95.3% (0.76). AA %: 16.2% (2.85).	Baseline mean (SE): ACE-I/ARB %: 93.9% (1.11). BB %: 95.0% (0.57). AA %: 19.6% (2.70).	Estimated treatment effect (95% CI): ACE-I/ARB %: 0.75 (95% CI -2.66 to 4.16). P=0.67.
	Hayes 2002: n=32 hospitals, 32/76 participants eligible.	Postintervention absolute change mean (SE): ACE-I/ARB %: 2.11% (1.30). BB %: 1.54% (0.87). AA %: -0.18% (1.75).	Postintervention absolute change mean (SE): ACE-I/ARB %: 1.36% (1.16). BB %: 0.49% (0.73). AA %: 3.93% (2.37).	AA %: -4.10 (95% CI -9.95 to 1.74). P=0.17.
	Laramée 2003: n=287 participants.	Difference between baseline and post-intervention %: ACE-I %: 3%.	Difference between baseline and postintervention %: ACE-I %: 3%.	No significance value reported.
	Panella 2009: n=14 hospitals, 429 participants analysed.	No (%) ACE-I/ARB: 121/141 (86%). No (%) BB: 91/141 (65%).	No (%) ACE-I/ARB: 115/145 (79%). No (%) BB: 89/145 (61%).	P=0.16. P=0.63.
	Philbin 2000: n=10 hospitals, 2906 participants analysed.	No (%) ACE-I %: 48/80 (60%).	No (%) ACE-I %: 5/12 (41.7%).	P=0.23.
	Tu 2009: n=86 hospitals, 17 544 participants analysed.	Baseline mean ACE-I %: 79%. Postintervention mean ACE-I %: 78%.	Baseline mean ACE-I %: 79% postintervention mean ACE-I %: 83%.	Intervention effect (95% CI): -7% (95% CI -20% to 5%). P=0.20.
	Laramée 2003: n=287 participants.	Absolute change % (95% CI): ACE-I/ARB %: 4.2% (95% CI 0.7% to 7.8%). BB %: 31.7% (95% CI 22.6% to 40.9%).	Absolute change % (95% CI): ACE-I/ARB %: -0.4% (95% CI -7.4% to 6.5%). BB %: 29.4% (95% CI 18.9% to 39.8%).	Absolute difference % (95% CI): 5.9% (95% CI 1.0% to 10.7%); P=0.02 3.5% (-6.1%, 13.1%); P=0.47.
Hospital readmission (up to 90 days after discharge)	Panella 2009: n=14 hospitals, 429 participants analysed.	No (%) ACE-I %: 49/131 (37%).	No (%) ACE-I %: 46/125 (37%).	P>0.99.
	Rich 1995: n=282 participants.	No (%) ACE-I %: 53/142 (37%).	No (%) ACE-I %: 94/140 (67%).	P=0.02.
	Sales 2013: n=137 participants.	No (%) ACE-I %: 5/70 (7%).	No (%) ACE-I %: 13/67 (19%).	Absolute risk reduction %: 12%. P=0.04.
30-day all-cause mortality	Sales 2013: n=137 participants.	No (%) ACE-I %: 5/70 (7%).	No (%) ACE-I %: 5/67 (7%).	Absolute risk reduction %: 0.4%. P=1.00.

Outcome	Trials	Intervention	Comparator	Significance
Hospital length of stay	Tu 2009; n=86 hospitals, 17 544 participants analysed.	Absolute change % (95% CI): -1.7% (95% CI -3.4% to 0%).	Absolute change % (95% CI): -1.6% to 1.9%.	Absolute difference % (95% CI): -1.1% (95% CI -3.2% to 0.9%); p=0.26.
	Panella 2009; n=14 hospitals, 429 participants analysed.	Mean (95% CI) days: 10.4 (95% CI 9.6 to 11.0).	Mean (95% CI) days: 11.4 (95% CI 10.5 to 12.3).	P=0.028.
Patient-level health-related quality of life	Philbin 2000; n=10 hospitals, 2906 participants analysed.	Baseline mean days: 8.0. Postintervention mean days: 6.2.	Baseline mean days: 7.7. Postintervention mean days: 7.0.	Intervention effect (95% CI): -1.1 (95% CI -2.9 to 0.7) days.
	Koelling 2005; n=223 participants.	MLHF score baseline mean (SD): 56 (23). MLHF score 30-day mean (SD): 38 (22). MLHF score 180-day mean (SD): 41 (22).	MLHF score baseline mean (SD): 59 (22). MLHF score 30-day mean (SD): 45 (25). MLHF score 180-day mean (SD): 42 (25).	No significance value reported. P=0.049. No significance value reported.
	Philbin 2000; n=10 hospitals, 2906 participants analysed.	LOL score baseline mean: 6.6. LOL score postintervention mean: 6.5.	LOL score baseline mean: 6.3. LOL score postintervention mean: 6.5.	Intervention effect (95% CI): -0.3 (95% CI -1.6 to 1.0).
	Rich 1995; n=282 participants.	NYHA class baseline mean: 2.2. NYHA class postintervention mean: 2.1. CHFQ mean (SD) change: 22.1 (20.8).	NYHA class baseline mean: 2.4. NYHA class post-intervention mean: 2.4. CHFQ mean (SD) change: 11.3 (16.4).	0 (95% CI -0.4 to 0.3). P=0.88. P=0.001.

* In patients with reduced left ventricular ejection fraction (ranging from 40.0% or <40.0%).

† CHFQ assessed in subset of 126 participants.

AA, aldosterone antagonist; ACE-I, ACE inhibitor; ARB, angiotensin receptor blocker; BB, beta-blocker; CHFQ, Chronic Heart Failure Questionnaire (higher scores reflect better quality of life); LOL, Ladder of Life (higher scores reflect better quality of life); MLHF, Minnesota Living with Heart Failure Questionnaire (lower scores reflect better quality of life); NYHA, New York Heart Association.

Summary of findings

Table 2

In-hospital heart failure quality improvement interventions compared with usual care				
Patient or population: hospitalised patients with heart failure				
Intervention: in-hospital heart failure quality improvement interventions				
Comparison: usual care				
Outcome	Effect on outcome	Number of hospitals and/or participants (studies)	Quality of the evidence (GRADE)	Comments
In-hospital mortality	Two of three trials (n=74 735) showed no effect of the intervention on in-hospital mortality (estimated treatment effect: -0.03, 95%CI -1.12 to 1.05; intervention effect: 1.0%, 95% CI -3.0% to 5.0%). One trial (n=429) had lower in-hospital mortality in the intervention (5.6%, 95% CI 2.5% to 8.7%) compared with usual care (15.4%, 95% CI 10.5% to 20.2%).	Hospitals=189. Participants=75164. (three cluster RCTs).	⊕⊕⊕ Low ^{*,†}	The point estimates vary, and the direction of effect is not consistent. [*] There are small number of included studies (n=3) but with high overall sample size. [†]
In-hospital medical therapy	One trial demonstrated a positive effect of the intervention towards increased in-hospital medical therapy for ACE-I (57.9% vs 40.0%) and BB (46.7% vs 10.2%) but no change in in-hospital diuretics (95.3% vs 95.8%).	Hospitals=14. Participants=429 (one cluster RCT).	⊕⊕⊕ Low ^{*,†}	Although the magnitude of sample size is high, only one study reported this outcome. [*] [†]
Discharge medical therapy	Five out of six trials (n=78 727) showed no effect of the intervention on discharge medical therapy for ACE-I/ARB (estimated treatment effect: 0.75, 95% CI -2.66 to 4.16; 3% vs 3%; 86% vs 79%; 60% vs 41.7%; intervention effect: -7%, 95% CI -20% to 5%). Three out of three trials (n=89 660) showed no effect of the intervention on discharge medical therapy for BB (estimated treatment effect: 1.05, 95% CI -1.17 to 3.27; 65% vs 61%; absolute difference: 3.5%, 95% CI -6.1% to 13.1%).	Hospitals=307. Participants=96 271. (five cluster RCTs and one RCT).	⊕⊕⊕ Moderate [*]	The direction of effect is inconsistent, and the point estimates vary across studies. [*] Magnitude of included studies is moderate (n=6) with high overall sample size.
Hospital readmission (up to 90 days after discharge)	Two out of three trials (n=419) showed a trend towards decreased hospital readmissions in the intervention compared with usual care (37% vs 67%; 7% vs 19%).	Participants=706 (three RCTs).	⊕⊕⊕ Low ^{*,†}	The point estimates vary and the direction of effect is not consistent. [*] There are small number of included studies (n=3) with moderate overall sample size. [†]
30-day all-cause mortality	Two out of two trials showed no effect of the intervention on 30-day all-cause mortality (7% vs 7%; absolute difference: -1.1%, 95% CI -3.2% to 0.9%).	Hospitals=86. Participants=17 681 (one cluster RCT, one RCT).	⊕⊕⊕ Low ¹²	Although the direction of effect is consistent, the point estimates vary in the setting of small number of included studies (n=2) with high overall sample size. ¹²
Hospital length of stay	The mean days in the intervention ranged from 6.2 to 10.4 days and in usual care from 7.0 to 11.4 days.	Hospitals=24. Participants=3335 (two cluster RCTs).	⊕⊕⊕ Low ¹²	The point estimates vary and the direction of effect is not consistent. [*] There are small number of included studies (n=2) with moderate overall sample size. [†]

In-hospital heart failure quality improvement interventions compared with usual care				
Patient or population: hospitalised patients with heart failure				
Intervention: in-hospital heart failure quality improvement interventions				
Comparison: usual care				
Outcome	Effect on outcome	Number of hospitals and/or participants (studies)	Quality of the evidence (GRADE)	Comments
Patient-level health-related quality of life	One out of three trials (n=282) showed a trend towards better quality of life in the intervention compared with usual care (mean change (SD): 22.1 (20.8) versus 11.3 (16.4)).	Hospitals=10; Participants=3411 (one cluster RCT, two RCTs).	⊕○○○ Very low ¹⁻³	The direction of effect is not consistent [*] in the setting of small number of included studies (n=3). All studies likely have high risk of detection bias in use of questionnaires to assess self-reported outcomes, [†]

^{*} Downgraded due to inconsistency.

[†] Downgraded due to imprecision.

[‡] Downgraded due to study limitations.

GRADE Working Group grades of evidence (Guyatt *et al.* BMJ 2008; 336 (7650):924–926).

High quality: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate quality: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low quality: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low quality: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

ACE-I, ACE inhibitor; ARB, angiotensin receptor blocker; BB, beta-blocker; cRCT, cluster randomised control trial; GRADE, Grading of Recommendations Assessment, Development and Evaluation; RCT, randomised control trial.