Transitional Care Interventions to Prevent Readmissions for Persons With Heart Failure

A Systematic Review and Meta-analysis

Cynthia Feltner, MD, MPH; Christine D. Jones, MD, MS; Crystal W. Cené, MD, MPH; Zhi-Jie Zheng, MD, PhD, MPH; Carla A. Sueta, MD, PhD; Emmanuel J.L. Coker-Schwimmer, MPH; Marina Arvanitis, MD; Kathleen N. Lohr, PhD, MPhil, MA; Jennifer C. Middleton, PhD; and Daniel E. Jonas, MD, MPH

Background: Nearly 25% of patients hospitalized with heart failure (HF) are readmitted within 30 days.

Purpose: To assess the efficacy, comparative effectiveness, and harms of transitional care interventions to reduce readmission and mortality rates for adults hospitalized with HF.

Data Sources: MEDLINE, Cochrane Library, CINAHL, ClinicalTrials.gov, and World Health Organization International Clinical Trials Registry Platform (1 January 1990 to late October 2013).

Study Selection: Two reviewers independently selected randomized, controlled trials published in English reporting a readmission or mortality rate within 6 months of an index hospitalization.

Data Extraction: One reviewer extracted data, and another checked accuracy. Two reviewers assessed risk of bias and graded strength of evidence (SOE).

Data Synthesis: Forty-seven trials were included. Most enrolled adults with moderate to severe HF and a mean age of 70 years. Few trials reported 30-day readmission rates. At 30 days, a high-intensity home-visiting program reduced all-cause readmission and the composite end point (all-cause readmission or death; low SOE). Over 3 to 6 months, home-visiting programs and multidisciplinary heart failure (MDS-HF) clinic interventions reduced all-cause readmission (high SOE). Home-visiting programs reduced HF-specific readmission and the composite end point (moderate SOE). Structured telephone support (STS) interventions reduced HF-specific readmission (high SOE) but not all-cause readmissions (moderate SOE). Home-visiting programs, MDS-HF clinics, and STS interventions produced a mortality benefit. Neither telemonitoring nor primarily educational interventions reduced readmission or mortality rates.

Limitations: Few trials reported 30-day readmission rates. Usual care was heterogeneous and sometimes not adequately described.

Conclusion: Home-visiting programs and MDS-HF clinics reduced all-cause readmission and mortality; STS reduced HF-specific readmission and mortality. These interventions should receive the greatest consideration by systems or providers seeking to implement transitional care interventions for persons with HF.

Primary Funding Source: Agency for Healthcare Research and Quality.

Ann Intern Med. 2014;160:774-784. www.annals.org
For author affiliations, see end of text.
This article was published online first at www.annals.org on 27 May 2014.

Heart failure (HF) is a leading cause of hospitalization and health care costs in the United States (1). Up to 25% of patients hospitalized with HF are readmitted within 30 days (2–5). Readmissions after an index hospitalization for HF are related to various conditions. An analysis of Medicare claims data from 2007 to 2009 found that 35% of readmissions within 30 days were for HF; the remainder were for diverse indications (for example, renal disorders, pneumonia, and arrhythmias) (2).

To reduce rehospitalization of Medicare patients, in October 2012, the Centers for Medicare & Medicaid Services began decreasing reimbursements to hospitals with excessive risk-standardized readmission (6). This policy incentivizes hospitals to develop programs to reduce readmission rates for persons with HF. Despite advances in the quality of acute and chronic HF disease management, knowledge gaps remain about effective interventions to support the transition of care for persons with HF.

Interventions designed to prevent readmissions among populations transitioning from one care setting to another are often called "transitional care interventions" (7, 8). They aim to avoid poor outcomes caused by uncoordinated care, such as preventable readmissions (9). Although no clear set of components defines transitional care interventions, they focus on patient or caregiver education, medication reconciliation, and coordination among health professionals involved in the transition.

We conducted a systematic review of transitional care interventions for persons with HF for the Effective Health Care Program of the Agency for Healthcare Research and Quality (AHRQ) (10). We included a broad range of intervention types (**Table 1**) applicable to adults transitioning from hospital to home that aimed to prevent readmissions. Although 30-day readmissions are the focus of quality measures, we also included readmissions measured over 3 to 6 months because these are common, costly, and potentially preventable (5). The full technical report addressed 5 questions (**Appendix Table 1**, available at www.annals.org). For this article, we focused on readmission and mortality outcomes.

Methods

We developed and followed a standard protocol. A technical report that details methods and includes complete search strategies and additional evidence tables is

available at www.effectivehealthcare.ahrq.gov/reports/final.cfm.

Data Sources and Searches

We searched MEDLINE, the Cochrane Library, and CINAHL for English-language and human-only studies published from 1 July 2007 to late October 2013, and we used a previous technology assessment on a similar topic to identify randomized, controlled trials (RCTs) published before 1 July 2007 (11). An experienced Evidence-based Practice Center librarian conducted the searches, and a second librarian reviewed them. We manually searched reference lists of pertinent reviews, included trials, and background articles on this topic to look for relevant citations our searches might have missed. We searched for relevant unpublished studies using ClinicalTrials.gov and the World Health Organization International Clinical Trials Registry Platform.

Study Selection

We developed inclusion and exclusion criteria with respect to populations, interventions, comparators, outcomes, timing, settings, and study designs (**Appendix Table 2**, available at www.annals.org). We included studies of adults recruited during or within 1 week of an index hospitalization for HF that compared a transitional care intervention with another eligible intervention or with usual care (that is, routine or standard care, as defined by the primary studies). We required that interventions include 1 or more of the following components: education of patient or caregiver delivered before or after discharge, planned or scheduled outpatient clinic visits (primary care or multidisciplinary heart failure [MDS-HF] clinic), home visits, telemonitoring, structured telephone support (STS), transition coach or case management, or interventions to increase provider continuity. We required studies to report a readmission rate, mortality rate, or the composite outcome (all-cause readmission or mortality). In the full report, we also assessed emergency department visits, acute care visits, hospital days of subsequent readmissions, quality of life, functional status, and caregiver or self-care burden (10).

Data Extraction and Risk-of-Bias Assessment

One team member extracted relevant data from each article, and a second team member reviewed all data extractions for completeness and accuracy.

We used predefined criteria based on the AHRQ Methods Guide for Comparative Effectiveness Reviews (12) to rate studies as having low, medium, high, or unclear risk of bias. Two reviewers independently assessed risk of bias for each study, and disagreements were resolved by consensus.

Data Synthesis and Analysis

We categorized intervention types primarily on the basis of the method and environment of delivery, as defined in **Table 1**. One investigator categorized the intervention, and a second team member reviewed the categorization. Disagreements were resolved by consensus. Given heterogeneity of the clinic-based interventions, we subcategorized these by clinic setting: MDS-HF, nurse-led HF, or primary care.

Table 1. **Transitional Care Interventions**

Category	Definition
Home-visiting programs	Home visits by clinicians, such as a nurse or pharmacist, who educate, reinforce self-care instructions, perform physical examination, or provide other care (e.g., physical therapy or medication reconciliation). These interventions are often referred to as nurse case management interventions, but they also can include home visits by a pharmacist or multidisciplinary team.
STS	Monitoring, education, or self-care management (or various combinations) using simple telephone technology after discharge in a structured format (e.g., series of scheduled calls with a specific goal, structured questioning, or use of decision-support software).
Telemonitoring	Remote monitoring of physiologic data (e.g., electrocardiogram, blood pressure, weight, pulse oximetry, or respiratory rate) with digital, broadband, satellite, wireless, or Bluetooth transmission to a monitoring center, with or without remote clinical visits (e.g., video monitoring).
Outpatient clinic–based	Services provided in one of several types of outpatient clinics: multidisciplinary HF, nurse-led HF, or primary care. The clinic-based intervention can be managed by a nurse or other provider and may also offer unstructured telephone support (e.g., patient hotline) outside clinic hours.
Primarily educational	Patient education (and self-care training) delivered before or at discharge by various personnel or methods: in person, interactive CD-ROM, or video education. Interventions in this category do not feature telemonitoring, home visits, or STS and are not delivered primarily through a clinic-based intervention. Follow-up telephone calls may occur to ascertain outcomes (e.g., readmission rates) but not to monitor patients' physiologic data.
Other	Unique interventions or interventions that do not fit into any of the other categories (e.g., individual peer support for patients with HF).

HF = heart failure; STS = structured telephone support.

We used DerSimonian–Laird random-effects models (13) for meta-analyses of outcomes reported by multiple studies that were sufficiently similar to justify combining results. We ran meta-analyses of trials that reported the number of deaths or number of persons readmitted in each group (and not total readmissions per group). When only the total number of readmissions per group was available, we contacted authors for additional data. When we could not obtain the number of persons readmitted, we did not include the results in meta-analyses; instead, we included the results in qualitative syntheses and considered them when grading the strength of evidence (SOE).

For readmission and mortality rates, we calculated risk ratios (RRs). We stratified analyses for each intervention category by outcome timing and separated rates reported at 30 days from those after 30 days (that is, rates reported over 3 to 6 months were combined). We did not include

studies rated as high or unclear risk of bias in our main analyses but included them in sensitivity analyses, which are available in the technical report (10); we describe them here only when they differed from primary analyses. We assessed statistical heterogeneity using the chi-square and I^2 statistics (14, 15). We calculated the number needed to treat (NNT) for readmission and mortality outcomes when we had statistically significant findings based on our primary analyses of trials rated as low or medium risk of bias, and we found at least low SOE for benefit. The NNT was derived from the RR and median usual care event rate using methods described in the Cochrane Handbook (16). We conducted meta-analyses using Stata, version 11.1 (StataCorp, College Station, Texas).

We did meta-analysis stratified by intensity in each intervention category when variation existed. The results of these subgroup analyses are available in the main report (10); we describe them here only when we found a difference in efficacy based on level of intensity. Given the heterogeneity of included interventions, we could not develop a single measure of intensity that could be applied to all intervention categories. For most interventions, we defined intensity as the duration, frequency, or periodicity of patient contact and categorized each intervention as low-, medium-, or high-intensity. We reserved the low-intensity category for interventions that included 1 episode of patient contact or few resources.

We graded SOE as high, moderate, low, or insufficient based on guidance established for the Evidence-based Practice Center program (17). The approach incorporates 4 key domains: risk of bias, consistency, directness, and precision. When only 1 study reported an outcome of interest, we usually graded the SOE as insufficient (primarily due to unknown consistency and imprecision); however, when similar interventions had consistent results at other time points, we graded the SOE as low. Two reviewers assessed each domain for each outcome, and differences were resolved by consensus.

Role of the Funding Source

The AHRQ funded this review, and AHRQ staff participated in the development of the scope of the work and reviewed draft manuscripts. Approval from AHRQ was required before the manuscript could be submitted for publication, but the authors are solely responsible for the content and the decision to submit it for publication.

RESULTS

Searches of all sources identified 2419 potentially relevant citations. We included 47 RCTs (**Appendix Figure 1**, available at www.annals.org). Trial characteristics are shown in **Appendix Table 3** (available at www.annals.org). Most trials compared a transitional care intervention with usual care; 2 directly compared more than 1 intervention (both rated high risk of bias) (18, 19). In general, trials included adults with a mean age of 70 years who were hospitalized with a primary diagnosis of HF. Most reported HF disease severity based on the New York Heart Association classification and included persons with moderate to severe HF. Twenty-nine trials reported mean ejection fraction. Of these, 27 enrolled persons with a mean ejection fraction less than 0.50 and 7 trials specified a reduced ejection fraction as an inclusion criterion. Across most trials, the majority of patients were prescribed an angiotensin-converting enzyme inhibitor or angiotensin-receptor blocker. The percentages of patients who were prescribed β-blockers at discharge varied widely across trials. Trials were conducted in a range of settings: academic medical centers, Department of Veterans Affairs hospitals, and community hospitals. Twenty-three were multicenter trials, and 23 were conducted in a single center. Twenty-six trials were conducted in the United States, and 21 were done in other developed countries.

In general, trials report usual care as "standard discharge instructions" or "follow-up with outpatient provider as usual." Most trials did not describe specific details, such as the type of clinic follow-up (for example, primary care vs. follow-up in a specialty clinic) or the timing of outpatient follow-up in the usual care group. We assessed most interventions as medium- or high-intensity (**Appendix Table 3**).

Fourteen RCTs compared a home-visiting program with usual care (20–33), and 1 trial compared a home-visiting program with telemonitoring (19). Five trials involved only 1 comprehensive home visit (20, 23, 24, 26, 33) after an index hospitalization; the remainder included several planned visits. In most trials, nurses conducted the home visits, most of which began within 7 days of discharge. Three trials included visits within 24 to 48 hours of discharge (28, 30, 31), and 3 trials specified that visits were done within 14 days of discharge (21, 25, 32).

Thirteen RCTs described in 15 publications compared STS with usual care (18, 34–45). Most trials averaged 1 or 2 calls during the intervention period, with the first contact occurring within 7 days of discharge. Interventions varied in whether predischarge education was delivered with STS. Most trials included a patient-initiated hotline for questions or additional support (34, 37, 38, 40–42, 44).

Eight trials evaluated telemonitoring. Five evaluated remote clinical data monitoring using equipment installed in a patient's home (generally delivered within 2 to 7 days of discharge) that transmitted data to a central site (19, 46–49). Three trials used specialized equipment to allow for video assessments and interactions with patients (18, 50–52); the equipment could also check clinical data, such as blood pressure, or included stethoscopes to allow remote auscultation.

Seven trials evaluated outpatient clinic–based interventions (53–60). Four were in MDS-HF specialty clinics (54–57, 59, 60), 2 were in nurse-led HF specialty clinics (53, 58), and 1 assessed enhanced access to primary care (61). All involved a series of scheduled outpatient clinic

Table 2. **Summary of Key Findings and SOE, by Outcome and Intervention Category***

Intervention Category	All-Cause Readmissions		HF-Specific Readmissions		Composite End Point		Mortality	
	30 d	3–6 mo	30 d	3–6 mo	30 d	3–6 mo	30 d	3–6 mo
Home-visiting program	Low†‡	High†	–§	Moderate†	Low†	Moderate†	Insufficient	Moderate†
STS	Insufficient	Moderate‖	Insufficient	High†	–§	Low‖	–§	Moderate†
Telemonitoring	Insufficient	Moderate‖	–§	Moderate‖	–§	–§	–§	Low‖
MDS-HF clinic	–§	High†	–§	Insufficient	–§	Moderate‖	–§	Moderate†
Nurse-led clinic	–§	Low‖	–§	Insufficient	–§	Insufficient	–§	Low‖
Primary care clinic	–§	Insufficient	–§	–§	–§	–§	–§	Insufficient
Primarily educational	–§	Insufficient	–§	Insufficient	–§	Low‖	–§	Low‖
Other	Insufficient	–§	–§	–§	–§	–§	Insufficient	–§

HF = heart failure; MDS = multidisciplinary; SOE = strength of evidence; STS = structured telephone support.
* SOE graded as low, moderate, high, or insufficient.
† Benefit was found (i.e., statistically significant reduction in readmission rate or mortality compared with usual care).
‡ Two home-visiting programs reported all-cause readmission at 30 d. The intervention studied by Naylor and colleagues (28) was of higher intensity and showed efficacy. The lower-intensity intervention studied by Jaarsma and colleagues (20) did not show efficacy at 30 d (low SOE; number need to treat, not applicable).
§ No trials in this category reported on an eligible outcome at this time point.
‖ No benefit was found (i.e., no statistically significant reduction in the outcome).

visits beginning within 7 days of discharge or enrollment, as well as individualized care planning. The 2 interventions described as "nurse-led" focused on patient education delivered by nurses during scheduled appointments (53, 58). Trials that described MDS-HF clinic interventions emphasized more physician contact and access to a multidisciplinary care team (cardiologists, dieticians, and pharmacists) than nurse-led clinics.

Four trials evaluated a primarily educational intervention. One compared the effects of a 1-hour, in-person patient education program with usual discharge care; no other components were delivered after discharge (62). Two trials investigated the effects of HF education delivered by technology through predischarge viewing of an educational CD-ROM (63) or a 60-minute video that was intended to be viewed at home (64). One trial featured predischarge nurse-led intensive education about HF symptoms and treatment followed by 1 telephone call 3 to 5 days after discharge to reinforce education (65).

We also included 2 interventions in an "other" category. One featured individual peer support (66), and 1 emphasized cognitive training for persons with HF and coexisting mild cognitive impairment (67).

Overall Summary of Key Findings

Table 2 summarizes our key findings by intervention category, outcome, and timing and notes when we had the following: sufficient evidence to grade the SOE and whether evidence supports benefit, insufficient evidence to make a determination, or no included trials that reported an outcome. **Table 3** presents more detailed results, including the RR (and its 95% CI) and the NNT (when applicable) for comparisons that included at least 1 trial reporting an outcome of interest.

Readmission and Mortality Rates at 30 Days

Figures 1 and **2** present our meta-analyses and RR calculations of trials reporting all-cause readmission and mortality, respectively. Results in both figures are stratified by intervention category and outcome timing. Meta-analysis and RR calculations for HF-specific readmission rates and the composite outcome are presented in **Appendix Figures 2** and **3** (available at www.annals.org).

Two home-visiting trials reported 30-day all-cause readmission rates. One trial evaluating a high-intensity home-visiting program found a lower risk for readmission among persons receiving home visits compared with the usual care group (RR, 0.34 [95% CI, 0.19 to 0.62]) (28). This intervention included a series of 8 planned home visits, the first within 24 hours of discharge. The other trial (20) assessed a medium-intensity intervention that included 1 telephone call within 7 days of discharge and 1 planned home visit within 10 days of discharge; this trial found no statistically significant reduction in all-cause readmissions (RR, 0.89 [CI, 0.43 to 1.85]). We concluded that high-intensity home-visiting programs (frequent home visits starting within 24 hours after discharge) reduce all-cause readmissions (low SOE), with an NNT of 6. Our SOE grade accounted for the consistency of similar interventions in reducing readmissions over 3 to 6 months (**Figure 1**). We also found low SOE for home-visiting programs in reducing the composite outcome at 30 days (**Table 3**) (28).

Four other trials across different intervention categories reported 30-day all-cause readmission: 1 STS trial (36), 2 telemonitoring trials (50, 52), and 1 trial of cognitive training (in persons with HF and coexisting cognitive dysfunction) (67). None of these interventions reduced 30-day all-cause readmission rates. One STS trial found no difference in the risk for 30-day HF-specific readmissions between persons receiving STS and those receiving usual care (36).

Readmission and Mortality Rates at 3 to 6 Months

All-Cause Readmissions

Both home-visiting programs and MDS-HF clinic interventions reduced all-cause readmissions over 3 to 6

Table 3. **Summary of Key Findings and SOE for Transitional Care Interventions: Readmission Rates and Mortality**

Intervention Category	Outcome	Outcome Timing	Trials (Participants), *n*	RR (95% CI)*	NNT	SOE
Home-visiting programs	All-cause readmission	30 d	2 (418)	High-intensity (1 study): 0.34 (0.19–0.62) Medium-intensity (1 study): 0.89 (0.43–1.85)	6 for high-intensity NA‖ for lower-intensity programs	Low‡ for benefit
	All-cause readmission	3–6 mo	9 (1563)	0.75 (0.68–0.86)	9	High for benefit
	HF-specific readmission	3–6 mo	1 (282)	0.51 (0.31–0.82)	7	Moderate† for benefit
	Composite end point	30 d	1 (239)	Hazard ratio (±SE): 0.869 ± 0.033 vs. 0.737 ± 0.041	NA	Low§¶ for benefit
	Composite end point	3–6 mo	4 (824)	Hazard ratio (±SE): 0.071 ± 0.045 vs. 0.558 ± 0.047 0.78 (CI, 0.65–0.94)	10	Moderate for benefit
	Mortality	30 d	1 (239)	1.03 (0.15–7.16)	NA	Insufficient
	Mortality	3–6 mo	8 (1693)	0.77 (0.60–0.997)	33	Moderate for benefit
STS	All-cause readmission	30 d	1 (134)	0.80 (0.38–1.65)	NA	Insufficient
	All-cause readmission	3–6 mo	8 (2166)	0.92 (0.77–1.10)	NA	Moderate for no benefit
	HF-specific readmission	30 d	1 (134)	0.63 (0.24–1.87)	NA	Insufficient
	HF-specific readmission	3–6 mo	7 (1790)	0.74 (0.61–0.90)	14	High for benefit
	Composite end point	3–6 mo	3 (977)	0.81 (0.58–1.12)	NA	Low for no benefit
	Mortality	3–6 mo	7 (2011)	0.74 (0.56–0.97)	27	Moderate for benefit
Telemonitoring	All-cause readmission	30 d	1 (168)	1.02 (0.64–1.63)	NA	Insufficient
	All-cause readmission	3–6 mo	3 (434)	1.11 (0.87–1.42)	NA	Moderate** for no benefit
	HF-specific readmission	3–6 mo	1 (182)	1.70 (0.82–3.51)	NA	Moderate** for no benefit
	Mortality	3–6 mo	3 (564)	0.93 (0.25–3.48)	NA	Low for no benefit
MDS-HF clinic	All-cause readmission	3–6 mo	2 (336)	0.70 (0.55–0.89)	8	High for benefit
	HF-specific readmission	3–6 mo	1 (106)	0.70 (0.29–1.70)	NA	Insufficient
	Composite end point	3–6 mo	2 (306)	0.80 (0.43–1.01)	NA	Moderate for no benefit
	Mortality	3–6 mo	3 (536)	0.56 (0.34–0.92)	18	Moderate for benefit
Nurse-led clinic	All-cause readmission	3–6 mo	2 (264)	0.88 (0.57–1.37)	NA	Low for no benefit
	HF-specific readmission	3–6 mo	1 (158)	0.95 (0.68–1.32)	NA	Insufficient
	Composite end point	3–6 mo	1 (106)	0.66 (0.43–1.01)	NA	Insufficient
	Mortality	3–6 mo	2 (264)	0.59 (0.12–3.03)	NA	Low for no benefit
Primary care clinic	All-cause readmission	3–6 mo	1 (443)	1.27 (1.05–1.54)	NA	Insufficient
	Mortality	3–6 mo	1 (443)	1.52 (0.88–2.63)	NA	Insufficient
Primarily educational	All-cause readmission	3–6 mo	1 (200)	1.14 (0.84–1.54)	NA	Insufficient
	HF-specific readmission	3–6 mo	1 (223)	0.53 (0.31–0.90)	NA	Insufficient
	Composite end point	3–6 mo	2 (423)	0.92 (0.58–1.47)	NA	Low
	Mortality	3–6 mo	2 (423)	1.20 (0.52–2.76)	NA	Low
Other (cognitive training)	All-cause readmission	30 d	1 (125)	1.15 (0.71–2.28)	NA	Insufficient
	Mortality	30 d	1 (125)	0.07 (0.00–1.12)	NA	Insufficient

HF = heart failure; MDS = multidisciplinary; NA = not applicable; NNT = number needed to treat; RR = risk ratio; SOE = strength of evidence; STS = structured telephone support.

* RRs from our meta-analyses or RR calculations unless otherwise specified. RRs <1 favor interventions over controls.

† Although only 1 trial reported total number of persons readmitted per group, we considered the findings consistent because 1 other trial reported on the number of readmissions per group and found a similar effect: Persons receiving home visits had fewer total HF readmissions than did those receiving usual care (measured as readmissions per patient-year alive; RR, 0.54; $P < 0.001$; $n = 200$) (24).

‡ Two home-visiting programs reported all-cause readmission at 30 d. The intervention studied by Naylor and colleagues (28) was of higher intensity and showed efficacy. The lower-intensity intervention studied by Jaarsma and colleagues (20) did not show efficacy at 30 d (low SOE; NNT, NA).

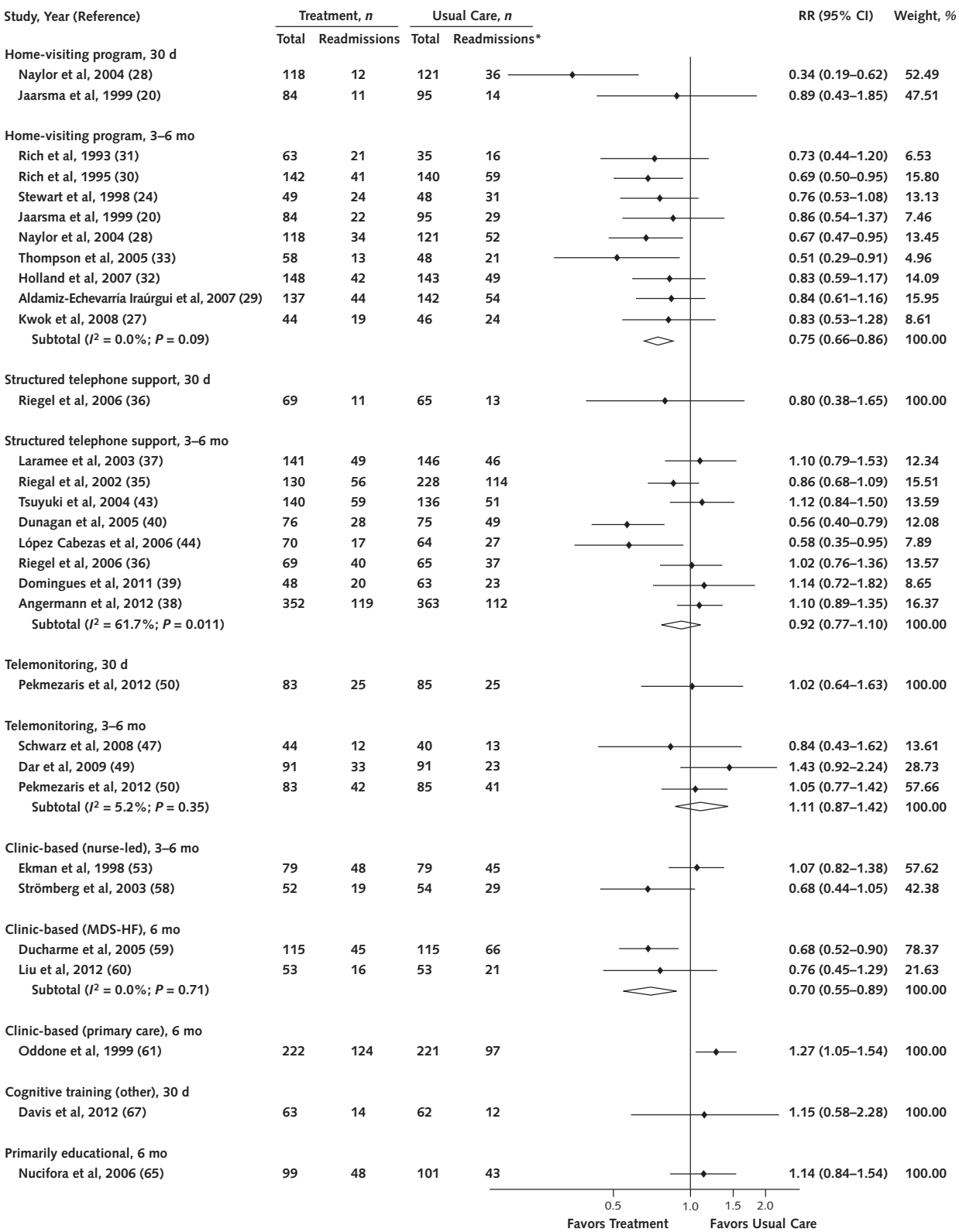
§ All-cause readmission or death.

‖ We did not calculate NNT because the RR was not statistically significant. We calculated NNT only for binary outcomes and not when outcomes were given as time to an event (i.e., hazard ratios).

¶ Although only 1 trial reported the number of persons alive and not readmitted at 30 d and 3 mo, we considered the consistency of similar programs reducing 3-mo readmissions rates when grading the SOE for this intervention at 30 d.

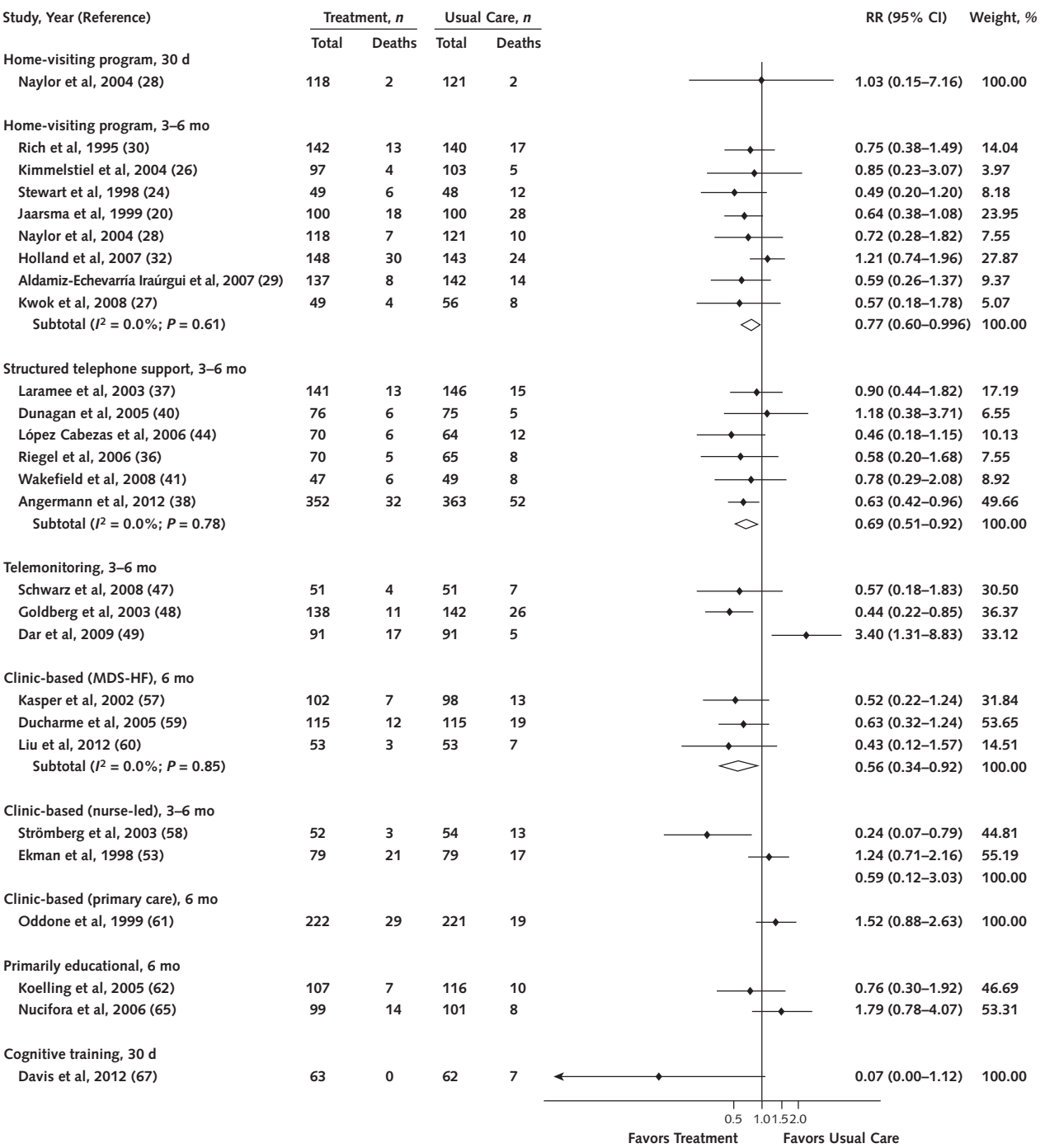
** Although only 1 trial reported on the number of persons readmitted, we considered this finding consistent given that 4 other telemonitoring trials reported the total number of readmissions per group (rather than the number of persons readmitted); all-cause readmissions did not differ between persons receiving telemonitoring and those receiving usual care at 30 d (44), 3 mo (43), or 6 mo (38, 40, 44).

Figure 1. **All-cause readmissions for transitional care interventions compared with usual care, by intervention category and outcome timing.**



Weights are from random-effects analysis. MDS-HF = multidisciplinary heart failure; RR = risk ratio.
* Number of people readmitted per group (not total readmissions per group).

Figure 2. **Mortality rate among persons receiving transitional care interventions compared with usual care, by intervention category and outcome timing.**



Weights are from random-effects analysis. MDS-HF = multidisciplinary heart failure; RR = risk ratio.

months (high SOE; NNT, 7 to 9). The STS and telemonitoring interventions were not effective in reducing the risk for all-cause readmission (moderate SOE for both). Similarly, nurse-led clinic interventions were not efficacious in reducing the risk for all-cause readmission (low SOE). One trial found that patients with HF who had enhanced access to primary care after discharge (through a Veterans Affairs health care setting) had a higher risk for all-cause readmission than those in the control group (61). However, because we had limited evidence from a single

trial and unknown consistency, we graded the evidence on increasing access to primary care as insufficient. Evidence was insufficient to determine whether primarily educational interventions were effective in reducing all-cause readmission.

HF-Specific Readmissions

Home-visiting programs and STS interventions both reduced the risk for HF-specific readmissions (moderate and high SOE, respectively; NNT, 7 to 14). Telemonitoring did not reduce the risk for HF-specific readmissions (moderate SOE). Evidence was insufficient about whether MDS-HF clinic interventions, nurse-led HF clinic interventions, or primarily educational interventions reduced HF-specific readmissions (1 trial with unknown consistency for each).

Composite Outcome

Few trials reported the composite outcome (all-cause readmission or death). Home-visiting programs reduced the composite outcome over 3 to 6 months (moderate SOE; NNT, 10). Structured telephone support, MDS-HF clinic interventions, and primarily educational interventions were not effective in reducing the risk for the composite outcome. We had insufficient evidence for nurse-led clinic interventions (58) and no evidence for other intervention categories.

Mortality

Figure 2 presents our meta-analysis of trials reporting mortality rates stratified by intervention category and outcome timing. The following interventions reduced mortality compared with usual care (moderate SOE): home-visiting programs (NNT, 33), MDS-HF clinic interventions (NNT, 18), and STS (NNT, 27). Telemonitoring, nurse-led clinics, and primarily educational interventions did not reduce mortality (low SOE). Evidence for a reduction in mortality was insufficient for primary care interventions and cognitive training programs.

Sensitivity Analysis

For most sensitivity analyses, results were similar to those of our primary analyses. Details and complete forest plots are available in the full report (10). We found 1 exception. When we added 3 trials rated as high or unclear risk of bias, the effect of home-visiting programs on mortality over 3 to 6 months was no longer statistically significant, although the estimates of effects were similar (RR, 0.85 vs. 0.77); however, the CI was less precise and crossed 1 (RR, 0.85 [CI, 0.68 to 1.05]). In no other cases did adding trials rated as high or unclear risk of bias significantly change the overall conclusions.

Discussion

Current clinical practice for the care of adults with HF after hospitalization varies greatly (68). Our findings provide guidance to quality improvement efforts aimed at reducing readmission and mortality rates for persons with HF. Home-visiting programs and MDS-HF clinic interventions currently have the best evidence for reducing all-cause readmissions and mortality up to 6 months after an index hospitalization for persons with HF. We found little evidence on whether interventions reduced 30-day readmissions.

Trials included adults with similarities in age and New York Heart Association scores. Included trials commonly excluded persons with end-stage renal or severe cardiovascular disease; thus, results may not be applicable to persons with high levels of coexisting illness. The trials we examined were conducted in various inpatient settings, and more than half of included trials were done in the United States. Our findings are, therefore, generally applicable to many hospital settings in the United States.

Most trials compared an intervention with "usual care." Whether usual care in trials published during the early 1990s is comparable to current practice is not clear. In general, trials did not report on specific details of usual care. However, median rates of readmission in the usual care groups of included trials are similar to readmission rates among Medicare beneficiaries (5). It is not clear whether variation in usual care across trials is a major factor in the applicability of findings because current clinical practice in the care of adults with HF after hospitalization is diverse and readmission rates vary by geographic location and insurance coverage (68, 69).

We identified systematic reviews during our searches that were relevant to our key questions. Prior reviews differed in scope in that they either excluded readmission outcomes measured before 6 months or included trials that enrolled stable samples of patients with HF recruited from outpatient settings (70–72). In addition, other reviews used different categorization strategies, which may have led to different conclusions. For example, 1 recent systematic review and network meta-analysis found no statistically significant effect of remote monitoring interventions on mortality or all-cause readmission up to 1 year; this review also combined STS and telemonitoring (70). A 2009 Cochrane review found that "case-management" interventions (home-visiting programs and telephone support) reduced all-cause mortality at 12 months (but not at 6 months) and reduced HF-specific readmissions at 6 months and 1 year (71). The interventions included in our review were heterogeneous and could probably be categorized using various approaches. We classified them in a manner that we believe is descriptive and informative for physicians interested in interventions that could be implemented during the transition from hospital to home.

Potential limitations of our review include publication bias and selective reporting. We searched for unpublished trials and outcomes but did not find direct evidence of either type of bias. Many of the included trials were published before trial registries (for example, ClinicalTrials

.gov) became available. Had we been able to consult such registries, we would have had greater certainty about the potential for either type of bias. Many of the included trials had methodological limitations introducing some risk of bias. Some trials did not clearly describe methods used for assessing readmissions, and methods for handling missing data varied. Finally, heterogeneity of outcome measures across trials (for example, different types of readmission rates) is a limitation. We addressed this (in part) by contacting authors for additional data on the number of persons readmitted per group (as opposed to total readmissions per group); 9 authors were contacted, and 5 provided additional data (26, 28, 30, 46, 58).

We identified important gaps in the evidence that future research could address. Future studies should evaluate whether interventions that reduce readmission rates over 3 to 6 months also reduce 30-day readmission rates and could directly compare 1 intervention with another (for example, home-visiting program vs. multidisciplinary clinic). We identified only 1 trial based in a primary care outpatient clinic. Given that many patients do not have access to specialty care (for example, in rural settings) or may prefer care based in primary care clinics, future studies should evaluate the efficacy of transitional care interventions in primary care clinics.

In summary, few trials reported 30-day readmission rates; 1 high-intensity home-visiting trial reduced all-cause readmission over 30 days (low SOE). At outcome timings over 3 to 6 months, home-visiting programs and MDS-HF clinic interventions reduced all-cause readmission and mortality; STS reduced HF-specific readmission and mortality but not all-cause readmission. These interventions should receive the greatest consideration by systems or providers seeking to implement transitional care interventions for persons with HF.

From University of North Carolina at Chapel Hill and Cecil G. Sheps Center for Health Services Research, Chapel Hill, North Carolina; University of Colorado, Aurora, Colorado; and RTI International, Research Triangle Park, North Carolina, and Rockville, Maryland.

Disclaimer: The views expressed in this manuscript do not represent and should not be construed to represent a determination or policy of the AHRQ or the U.S. Department of Health and Human Services.

Acknowledgment: The authors thank Carol Woodell of RTI International for her project management expertise; Loraine Monroe of RTI International for editing and formatting the technical report; and Christine Chang, MD, MPH, AHRQ task order officer, for her considerable support, commitment, and contributions.

Grant Support: In part by AHRQ (grant HHSA290201200008I) and the U.S. Department of Health and Human Services (contract HHSA29032003T).

Disclosures: Disclosures can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M14-0083.

Requests for Single Reprints: Cynthia Feltner, MD, MPH, Department of Medicine, University of North Carolina at Chapel Hill, 5034 Old Clinic Building, CB 7110, Chapel Hill, NC 27599; e-mail, cindy_feltner@med.unc.edu.

Current author addresses and author contributions are available at www.annals.org.

References

1. **Centers for Medicare & Medicaid Services Office of Information Services.** Medicare ranking for all short-stay hospitals by discharges: fiscal year 2005 versus 2004. Baltimore: Centers for Medicare & Medicaid Services; 2006. Accessed at www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/MedicareFeeforSvcPartsAB/downloads/SSDischarges0405.pdf on 18 December 2012.

2. **Dharmarajan K, Hsieh AF, Lin Z, Bueno H, Ross JS, Horwitz LI, et al.** Diagnoses and timing of 30-day readmissions after hospitalization for heart failure, acute myocardial infarction, or pneumonia. JAMA. 2013;309:355-63. [PMID: 23340637]

3. **Bueno H, Ross JS, Wang Y, Chen J, Vidán MT, Normand SL, et al.** Trends in length of stay and short-term outcomes among Medicare patients hospitalized for heart failure, 1993-2006. JAMA. 2010;303:2141-7. [PMID: 20516414]

4. **Bernheim SM, Grady JN, Lin Z, Wang Y, Wang Y, Savage SV, et al.** National patterns of risk-standardized mortality and readmission for acute myocardial infarction and heart failure. Update on publicly reported outcomes measures based on the 2010 release. Circ Cardiovasc Qual Outcomes. 2010;3:459-67. [PMID: 20736442]

5. **Jencks SF, Williams MV, Coleman EA.** Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med. 2009;360:1418-28. [PMID: 19339721]

6. **Centers for Medicare & Medicaid Services.** Readmissions Reduction Program. Baltimore: Centers for Medicare & Medicaid Services; 2013. Accessed at www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html on 6 September 2013.

7. **Naylor MD, Aiken LH, Kurtzman ET, Olds DM, Hirschman KB.** The care span: The importance of transitional care in achieving health reform. Health Aff (Millwood). 2011;30:746-54. [PMID: 21471497]

8. **Stauffer BD, Fullerton C, Fleming N, Ogola G, Herrin J, Stafford PM, et al.** Effectiveness and cost of a transitional care program for heart failure: a prospective study with concurrent controls. Arch Intern Med. 2011;171:1238-43. [PMID: 21788541]

9. **Coleman EA, Boult C; American Geriatrics Society Health Care Systems Committee.** Improving the quality of transitional care for persons with complex care needs. J Am Geriatr Soc. 2003;51:556-7. [PMID: 12657079]

10. **Feltner C, Jones CD, Cené CW, Zheng Z, Sueta CA, Coker-Schwimmer EJL, et al.** Transitional care interventions to prevent readmissions for people with heart failure: systematic review. (Prepared by the RTI-UNC Evidence-based Practice Center under contract HHSA 290-2012-00008-I and HHSA 290-32003-T.) Rockville, MD: Agency for Healthcare Research and Quality; 2014. [Forthcoming]

11. **Raman G, DeVine D, Lau J.** Nonpharmacologic interventions for postdischarge care in heart failure: Technology assessment report. (Prepared by the Tufts-New England Medical Center Evidence-based Practice Center under contract 290-02-0022.) Rockville, MD: Agency for Healthcare Research and Quality; 2008.

12. **Viswanathan M, Ansari MT, Berkman ND, Chang S, Hartling L, McPheeters LM, et al.** Assessing the risk of bias of individual studies in systematic reviews of health care interventions. In: Methods Guide for Effectiveness and Comparative Effectiveness Reviews. AHRQ publication no. 10(14)-EHC063-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2012.

13. **Sutton AJ, Abrams KR, Jones DR, Sheldon TA, Song F.** Methods for Meta-Analysis in Medical Research. Chichester, United Kingdom: J Wiley; 2000.

14. **Higgins JP, Thompson SG.** Quantifying heterogeneity in a meta-analysis. Stat Med. 2002;21:1539-58. [PMID: 12111919]

15. **Higgins JP, Thompson SG, Deeks JJ, Altman DG.** Measuring inconsistency in meta-analyses. BMJ. 2003;327:557-60. [PMID: 12958120]

16. **Schünemann HJ, Oxman AD, Vist GE, Higgins JPT, Deeks JJ, Glasziou P, et al.** Chapter 12: Interpreting results and drawing conclusions. In: Higgins JPT,

Green ST, eds. Cochrane Handbook for Systematic Reviews of Interventions. Version 5.1.0, updated March 2011. Oxford, United Kingdom: The Cochrane Collaboration; 2011. Accessed at www.cochrane-handbook.org on 10 October 2013.

17. **Owens DK, Lohr KN, Atkins D, Treadwell JR, Reston JT, Bass EB, et al.** AHRQ series paper 5: grading the strength of a body of evidence when comparing medical interventions—Agency for Healthcare Research and Quality and the Effective Health-Care Program. J Clin Epidemiol. 2010;63:513-23. [PMID: 19595577]

18. **Jerant AF, Azari R, Nesbitt TS.** Reducing the cost of frequent hospital admissions for congestive heart failure: a randomized trial of a home telecare intervention. Med Care. 2001;39:1234-45. [PMID: 11606877]

19. **Benatar D, Bondmass M, Ghitelman J, Avitall B.** Outcomes of chronic heart failure. Arch Intern Med. 2003;163:347-52. [PMID: 12578516]

20. **Jaarsma T, Halfens R, Huijer Abu-Saad H, Dracup K, Gorgels T, van Ree J, et al.** Effects of education and support on self-care and resource utilization in patients with heart failure. Eur Heart J. 1999;20:673-82. [PMID: 10208788]

21. **Sethares KA, Elliott K.** The effect of a tailored message intervention on heart failure readmission rates, quality of life, and benefit and barrier beliefs in persons with heart failure. Heart Lung. 2004;33:249-60. [PMID: 15252415]

22. **Triller DM, Hamilton RA.** Effect of pharmaceutical care services on outcomes for home care patients with heart failure. Am J Health Syst Pharm. 2007; 64:2244-9. [PMID: 17959576]

23. **Stewart S, Marley JE, Horowitz JD.** Effects of a multidisciplinary, home-based intervention on unplanned readmissions and survival among patients with chronic congestive heart failure: a randomised controlled study. Lancet. 1999; 354:1077-83. [PMID: 10509499]

24. **Stewart S, Pearson S, Horowitz JD.** Effects of a home-based intervention among patients with congestive heart failure discharged from acute hospital care. Arch Intern Med. 1998;158:1067-72. [PMID: 9605777]

25. **Pugh LC, Havens DS, Xie S, Robinson JM, Blaha C.** Case management for elderly persons with heart failure: the quality of life and cost outcomes. MEDSURG Nursing. 2001;10:71-8.

26. **Kimmelstiel C, Levine D, Perry K, Patel AR, Sadaniantz A, Gorham N, et al.** Randomized, controlled evaluation of short- and long-term benefits of heart failure disease management within a diverse provider network: the SPAN-CHF trial. Circulation. 2004;110:1450-5. [PMID: 15313938]

27. **Kwok T, Lee J, Woo J, Lee DT, Griffith S.** A randomized controlled trial of a community nurse-supported hospital discharge programme in older patients with chronic heart failure. J Clin Nurs. 2008;17:109-17. [PMID: 18088263]

28. **Naylor MD, Brooten DA, Campbell RL, Maislin G, McCauley KM, Schwartz JS.** Transitional care of older adults hospitalized with heart failure: a randomized, controlled trial. J Am Geriatr Soc. 2004;52:675-84. [PMID: 15086645]

29. **Aldamiz-Echevarría Iraúrgui B, Muñiz J, Rodríguez-Fernández JA, Vidán-Martínez L, Silva-César M, Lamelo-Alfonsín F, et al.** [Randomized controlled clinical trial of a home care unit intervention to reduce readmission and death rates in patients discharged from hospital following admission for heart failure]. Rev Esp Cardiol. 2007;60:914-22. [PMID: 17915147]

30. **Rich MW, Beckham V, Wittenberg C, Leven CL, Freedland KE, Carney RM.** A multidisciplinary intervention to prevent the readmission of elderly patients with congestive heart failure. N Engl J Med. 1995;333:1190-5. [PMID: 7565975]

31. **Rich MW, Vinson JM, Sperry JC, Shah AS, Spinner LR, Chung MK, et al.** Prevention of readmission in elderly patients with congestive heart failure: results of a prospective, randomized pilot study. J Gen Intern Med. 1993;8:585-90. [PMID: 8289096]

32. **Holland R, Brooksby I, Lenaghan E, Ashton K, Hay L, Smith R, et al.** Effectiveness of visits from community pharmacists for patients with heart failure: HeartMed randomised controlled trial. BMJ. 2007;334:1098. [PMID: 17452390]

33. **Thompson DR, Roebuck A, Stewart S.** Effects of a nurse-led, clinic and home-based intervention on recurrent hospital use in chronic heart failure. Eur J Heart Fail. 2005;7:377-84. [PMID: 15718178]

34. **Barth V.** A nurse-managed discharge program for congestive heart failure patients: outcomes and costs. Home Health Care Manag Pract. 2001;13:436-43.

35. **Riegel B, Carlson B, Kopp Z, LePetri B, Glaser D, Unger A.** Effect of a standardized nurse case-management telephone intervention on resource use in patients with chronic heart failure. Arch Intern Med. 2002;162:705-12. [PMID: 11911726]

36. **Riegel B, Carlson B, Glaser D, Romero T.** Randomized controlled trial of telephone case management in Hispanics of Mexican origin with heart failure. J Card Fail. 2006;12:211-9. [PMID: 16624687]

37. **Laramee AS, Levinsky SK, Sargent J, Ross R, Callas P.** Case management in a heterogeneous congestive heart failure population: a randomized controlled trial. Arch Intern Med. 2003;163:809-17. [PMID: 12695272]

38. **Angermann CE, Störk S, Gelbrich G, Faller H, Jahns R, Frantz S, et al; Competence Network Heart Failure.** Mode of action and effects of standardized collaborative disease management on mortality and morbidity in patients with systolic heart failure: the Interdisciplinary Network for Heart Failure (INH) study. Circ Heart Fail. 2012;5:25-35. [PMID: 21956192]

39. **Domingues FB, Clausell N, Aliti GB, Dominguez DR, Rabelo ER.** Education and telephone monitoring by nurses of patients with heart failure: randomized clinical trial. Arq Bras Cardiol. 2011;96:233-9. [PMID: 21308343]

40. **Dunagan WC, Littenberg B, Ewald GA, Jones CA, Emery VB, Waterman BM, et al.** Randomized trial of a nurse-administered, telephone-based disease management program for patients with heart failure. J Card Fail. 2005;11:358-65. [PMID: 15948086]

41. **Wakefield BJ, Ward MM, Holman JE, Ray A, Scherubel M, Burns TL, et al.** Evaluation of home telehealth following hospitalization for heart failure: a randomized trial. Telemed J E Health. 2008;14:753-61. [PMID: 18954244]

42. **Rainville EC.** Impact of pharmacist interventions on hospital readmissions for heart failure. Am J Health Syst Pharm. 1999;56:1339-42. [PMID: 10683133]

43. **Tsuyuki RT, Fradette M, Johnson JA, Bungard TJ, Eurich DT, Ashton T, et al.** A multicenter disease management program for hospitalized patients with heart failure. J Card Fail. 2004;10:473-80. [PMID: 15599837]

44. **López Cabezas C, Falces Salvador C, Cubí Quadrada D, Arnau Bartés A, Ylla Boré M, Muro Perea N, et al.** Randomized clinical trial of a postdischarge pharmaceutical care program vs regular follow-up in patients with heart failure. Farm Hosp. 2006;30:328-42. [PMID: 17298190]

45. **Duffy JR, Hoskins LM, Dudley-Brown S.** Improving outcomes for older adults with heart failure: a randomized trial using a theory-guided nursing intervention. J Nurs Care Qual. 2010;25:56-64. [PMID: 19512945]

46. **Dendale P, De Keulenaer G, Troisfontaines P, Weytjens C, Mullens W, Elegeert I, et al.** Effect of a telemonitoring-facilitated collaboration between general practitioner and heart failure clinic on mortality and rehospitalization rates in severe heart failure: the TEMA-HF 1 (TElemonitoring in the MAnagement of Heart Failure) study. Eur J Heart Fail. 2012;14:333-40. [PMID: 22045925]

47. **Schwarz KA, Mion LC, Hudock D, Litman G.** Telemonitoring of heart failure patients and their caregivers: a pilot randomized controlled trial. Prog Cardiovasc Nurs. 2008;23:18-26. [PMID: 18326990]

48. **Goldberg LR, Piette JD, Walsh MN, Frank TA, Jaski BE, Smith AL, et al; WHARF Investigators.** Randomized trial of a daily electronic home monitoring system in patients with advanced heart failure: the Weight Monitoring in Heart Failure (WHARF) trial. Am Heart J. 2003;146:705-12. [PMID: 14564327]

49. **Dar O, Riley J, Chapman C, Dubrey SW, Morris S, Rosen SD, et al.** A randomized trial of home telemonitoring in a typical elderly heart failure population in North West London: results of the Home-HF study. Eur J Heart Fail. 2009;11:319-25. [PMID: 19174529]

50. **Pekmezaris R, Mitzner I, Pecinka KR, Nouryan CN, Lesser ML, Siegel M, et al.** The impact of remote patient monitoring (telehealth) upon Medicare beneficiaries with heart failure. Telemed J E Health. 2012;18:101-8. [PMID: 22283360]

51. **Woodend AK, Sherrard H, Fraser M, Stuewe L, Cheung T, Struthers C.** Telehome monitoring in patients with cardiac disease who are at high risk of readmission. Heart Lung. 2008;37:36-45. [PMID: 18206525]

52. **Jerant AF, Azari R, Martinez C, Nesbitt TS.** A randomized trial of telenursing to reduce hospitalization for heart failure: patient-centered outcomes and nursing indicators. Home Health Care Serv Q. 2003;22:1-20. [PMID: 12749524]

53. **Ekman I, Andersson B, Ehnfors M, Matejka G, Persson B, Fagerberg B.** Feasibility of a nurse-monitored, outpatient-care programme for elderly patients with moderate-to-severe, chronic heart failure. Eur Heart J. 1998;19:1254-60. [PMID: 9740348]

54. **McDonald K, Ledwidge M, Cahill J, Kelly J, Quigley P, Maurer B, et al.** Elimination of early rehospitalization in a randomized, controlled trial of multidisciplinary care in a high-risk, elderly heart failure population: the potential contributions of specialist care, clinical stability and optimal angiotensin-

converting enzyme inhibitor dose at discharge. Eur J Heart Fail. 2001;3:209-15. [PMID: 11246059]
55. **McDonald K, Ledwidge M, Cahill J, Quigley P, Maurer B, Travers B, et al.** Heart failure management: multidisciplinary care has intrinsic benefit above the optimization of medical care. J Card Fail. 2002;8:142-8. [PMID: 12140806]
56. **Ledwidge M, Barry M, Cahill J, Ryan E, Maurer B, Ryder M, et al.** Is multidisciplinary care of heart failure cost-beneficial when combined with optimal medical care? Eur J Heart Fail. 2003;5:381-9. [PMID: 12798838]
57. **Kasper EK, Gerstenblith G, Hefter G, Van Anden E, Brinker JA, Thiemann DR, et al.** A randomized trial of the efficacy of multidisciplinary care in heart failure outpatients at high risk of hospital readmission. J Am Coll Cardiol. 2002;39:471-80. [PMID: 11823086]
58. **Strömberg A, Mårtensson J, Fridlund B, Levin LA, Karlsson JE, Dahlström U.** Nurse-led heart failure clinics improve survival and self-care behaviour in patients with heart failure: results from a prospective, randomised trial. Eur Heart J. 2003;24:1014-23. [PMID: 12788301]
59. **Ducharme A, Doyon O, White M, Rouleau JL, Brophy JM.** Impact of care at a multidisciplinary congestive heart failure clinic: a randomized trial. CMAJ. 2005;173:40-5. [PMID: 15997043]
60. **Liu MH, Wang CH, Huang YY, Tung TH, Lee CM, Yang NI, et al.** Edema index-guided disease management improves 6-month outcomes of patients with acute heart failure. Int Heart J. 2012;53:11-7. [PMID: 22398670]
61. **Oddone EZ, Weinberger M, Giobbie-Hurder A, Landsman P, Henderson W.** Enhanced access to primary care for patients with congestive heart failure. Veterans Affairs Cooperative Study Group on Primary Care and Hospital Readmission. Eff Clin Pract. 1999;2:201-9. [PMID: 10623052]
62. **Koelling TM, Johnson ML, Cody RJ, Aaronson KD.** Discharge education improves clinical outcomes in patients with chronic heart failure. Circulation. 2005;111:179-85. [PMID: 15642765]
63. **Linné AB, Liedholm H.** Effects of an interactive CD-program on 6 months readmission rate in patients with heart failure—a randomised, controlled trial [NCT00311194]. BMC Cardiovasc Disord. 2006;6:30. [PMID: 16796760]
64. **Albert NM, Buchsbaum R, Li J.** Randomized study of the effect of video education on heart failure healthcare utilization, symptoms, and self-care behaviors. Patient Educ Couns. 2007;69:129-39. [PMID: 17913440]
65. **Nucifora G, Albanese MC, De Biaggio P, Caliandro D, Gregori D, Goss P, et al.** Lack of improvement of clinical outcomes by a low-cost, hospital-based heart failure management programme. J Cardiovasc Med (Hagerstown). 2006;7:614-22. [PMID: 16858241]
66. **Riegel B, Carlson B.** Is individual peer support a promising intervention for persons with heart failure? J Cardiovasc Nurs. 2004;19:174-83. [PMID: 15191260]
67. **Davis KK, Mintzer M, Dennison Himmelfarb CR, Hayat MJ, Rotman S, Allen J.** Targeted intervention improves knowledge but not self-care or readmissions in heart failure patients with mild cognitive impairment. Eur J Heart Fail. 2012;14:1041-9. [PMID: 22736737]
68. **Kociol RD, Peterson ED, Hammill BG, Flynn KE, Heidenreich PA, Piña IL, et al.** National survey of hospital strategies to reduce heart failure readmissions: findings from the Get With the Guidelines-Heart Failure registry. Circ Heart Fail. 2012;5:680-7. [PMID: 22933525]
69. **Allen LA, Smoyer Tomic KE, Smith DM, Wilson KL, Agodoa I.** Rates and predictors of 30-day readmission among commercially insured and Medicaid-enrolled patients hospitalized with systolic heart failure. Circ Heart Fail. 2012;5:672-9. [PMID: 23072736]
70. **Pandor A, Gomersall T, Stevens JW, Wang J, Al-Mohammad A, Bakhai A, et al.** Remote monitoring after recent hospital discharge in patients with heart failure: a systematic review and network meta-analysis. Heart. 2013;99:1717-26. [PMID: 23680885]
71. **Takeda A, Taylor SJ, Taylor RS, Khan F, Krum H, Underwood M.** Clinical service organisation for heart failure. Cochrane Database Syst Rev. 2012;9:CD002752. [PMID: 22972058]
72. **Inglis SC, Clark RA, McAlister FA, Ball J, Lewinter C, Cullington D, et al.** Structured telephone support or telemonitoring programmes for patients with chronic heart failure. Cochrane Database Syst Rev. 2010:CD007228. [PMID: 20687083]

Current Author Addresses: Drs. Feltner and Jonas: Department of Medicine, University of North Carolina at Chapel Hill, 5034 Old Clinic Building, CB 7110, Chapel Hill, NC 27599.
Dr. Jones: University of Colorado School of Medicine, Mail Stop F782, 12401 East 17th Avenue, Aurora, CO 80045.
Drs. Cené and Arvanitis: Division of General Medicine, University of North Carolina at Chapel Hill, 5039 Old Clinic Building, CB 7110, Chapel Hill, NC 27599.
Dr. Zheng: RTI International, 6110 Executive Boulevard, Suite 902, Rockville, MD 20852.
Dr. Sueta: UNC Center for Heart & Vascular Care, 6th Floor, Burnette-Womack Building, 160 Dental Circle, CB 7075, Chapel Hill, NC 27599.
Mr. Coker-Schwimmer and Dr. Middleton: RTI-UNC Evidence-based Practice Center, Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill, CB 7590, Chapel Hill, NC 27599.
Dr. Lohr: RTI International, 3040 Cornwallis Road, PO Box 12194, Research Triangle Park, NC 27709.

Author Contributions: Conception and design: C. Feltner, C.D. Jones, C.W. Cené, Z.J. Zheng, D.E. Jonas.
Analysis and interpretation of the data: C. Feltner, C.D. Jones, C.W. Cené, Z.J. Zheng, C.A. Sueta, E.J.L. Coker-Schwimmer, M. Arvanitis, K.N. Lohr, D.E. Jonas.
Drafting of the article: C. Feltner, C.W. Cené, Z.J. Zheng, E.J.L. Coker-Schwimmer, M. Arvanitis, K.N. Lohr, D.E. Jonas.
Critical revision of the article for important intellectual content: C. Feltner, C.D. Jones, C.W. Cené, Z.J. Zheng, E.J.L. Coker-Schwimmer, K.N. Lohr, D.E. Jonas.
Final approval of the article: C. Feltner, C.D. Jones, C.W. Cené, Z.J. Zheng, C.A. Sueta, M. Arvanitis, K.N. Lohr, D.E. Jonas.
Provision of study materials or patients: Z.J. Zheng.
Statistical expertise: C. Feltner, D.E. Jonas.
Obtaining of funding: D.E. Jonas.
Administrative, technical, or logistic support: C. Feltner, E.J.L. Coker-Schwimmer, K.N. Lohr, J.C. Middleton, D.E. Jonas.
Collection and assembly of data: C. Feltner, C.D. Jones, C.A. Sueta, E.J.L. Coker-Schwimmer, M. Arvanitis, J.C. Middleton, D.E. Jonas.

Web-Only Reference

73. **Wakefield BJ, Holman JE, Ray A, Scherubel M, Burns TL, Kienzle MG, et al.** Outcomes of a home telehealth intervention for patients with heart failure. J Telemed Telecare. 2009;15:46-50. [PMID: 19139220]

Appendix Table 1. **Scope and Key Questions***

Key Question	Question
1	Among adults who have been admitted for heart failure, do transitional care interventions increase or decrease the following health care utilization rates? a. Readmission rates b. Emergency department visits c. Acute care visits d. Hospital days (of subsequent readmissions)
2	Among adults who have been admitted for heart failure, do transitional care interventions increase or decrease the following health and social outcomes? a. Mortality rate b. Functional status c. Quality of life d. Caregiver burden e. Self-care burden
3	a. What are the components of effective interventions? b. Among effective interventions, are particular components necessary? c. Among multicomponent interventions, do particular components add benefit?
4	a. Does the effectiveness of interventions differ on the basis of intensity (e.g., duration, frequency, or periodicity) of the interventions? b. Does the effectiveness of interventions differ on the basis of delivery personnel (e.g., nurse or pharmacist)? c. Does the effectiveness of interventions differ on the basis of method of communication (e.g., face-to-face, telephone, or Internet)?
5	Do transitional care interventions differ in effectiveness or harms for subgroups of patients based on age, sex, race, ethnicity, disease severity (left ventricular ejection fraction or New York Heart Association classification), coexisting conditions, or socioeconomic status?

* In the article, we present our findings from only key questions 1a and 2a. We also describe our findings from key question 4a only when we found evidence that efficacy of interventions differed on the basis of intensity.

Appendix Table 2. **Inclusion and Exclusion Criteria for Studies of Transitional Care Interventions for Patients Hospitalized for HF**

Category	Inclusion Criteria	Exclusion Criteria
Population	Adults (aged ≥18 y) with HF requiring inpatient admission Recruited during or immediately after an index hospitalization for HF*	Children and adolescents aged <18 y
Interventions	Any transitional care interventions aimed at reducing readmissions, including ≥1 of the following components: Education to patient or caregiver (or both), delivered before or after discharge (or both) Discharge planning Appointment scheduling before discharge Increased planned or scheduled outpatient clinic visits (primary care, multidisciplinary HF) Home visits Telemonitoring (including remote clinical visits) Telephone support Transition coach or case management Interventions to increase provider continuity (same provider between inpatient and outpatient care)	NT-proBNP–guided therapy Pharmacotherapy (e.g., randomized trials of medication compared with placebo) Physician training (e.g., continuing medical education on evidence-based treatment for management of patients with HF) Surgical interventions or invasive procedures (e.g., left ventricular assist device, ultrafiltration, or dialysis) Technology aimed at guiding evaluation of patient volume status (e.g., pulmonary artery pressure sensor or segmental multifrequency bioelectrical impedance analysis) Hospital-at-home interventions
Comparators	Usual care, routine care, or standard care (as defined by the primary studies) Comparison of 1 intervention with another eligible one	Comparison of one intervention with an excluded one
Outcomes	KQ1: Readmission rates or the composite outcome (all-cause readmission or death), emergency department visits, acute care visits, or all-cause hospital days (of subsequent readmissions) KQ2: Mortality, quality of life, functional status‡, caregiver or self-care burden KQ3: All-cause readmissions, mortality, and the composite outcome (all-cause readmission or death) KQ4: All-cause readmission and mortality KQ5: Subgroups: any outcome eligible for KQ1 or KQ2	Trials that reported only an eligible quality-of-life or functional status outcome (and no readmission or mortality rate) were excluded from the analysis unless they accompanied a trial that measured readmission rates. Other composite end points (e.g., all-cause readmission or emergency department visits) were excluded.
Timing of outcome measurement†	Outcomes (readmissions, deaths, or other outcomes) occurring ≤6 mo from the index hospitalization	Outcomes measured any time after 6 mo
Length of follow-up	≥30 d	<30 d
Period	Studies published from 1990 to 29 October 2013	Studies published before 1990
Settings	Interventions occurring during the index hospitalization (before discharge) Interventions initiated in an outpatient setting after the index hospitalization Interventions bridging the transition from inpatient to outpatient care	All other settings (e.g., discharge to a skilled nursing facility or rehabilitation center)
Publication language	English	Other
Admissible evidence (study design and other criteria)	Original research Eligible study designs included the following: For all KQs: randomized, controlled trials For caregiver burden and self-care burden: nonrandomized, controlled trials or prospective cohort studies with an eligible comparison group	Case series Case reports Nonsystematic reviews Systematic reviews Editorials Letters to the editor Case–control studies Retrospective cohort studies Studies with historical, rather than concurrent, control groups

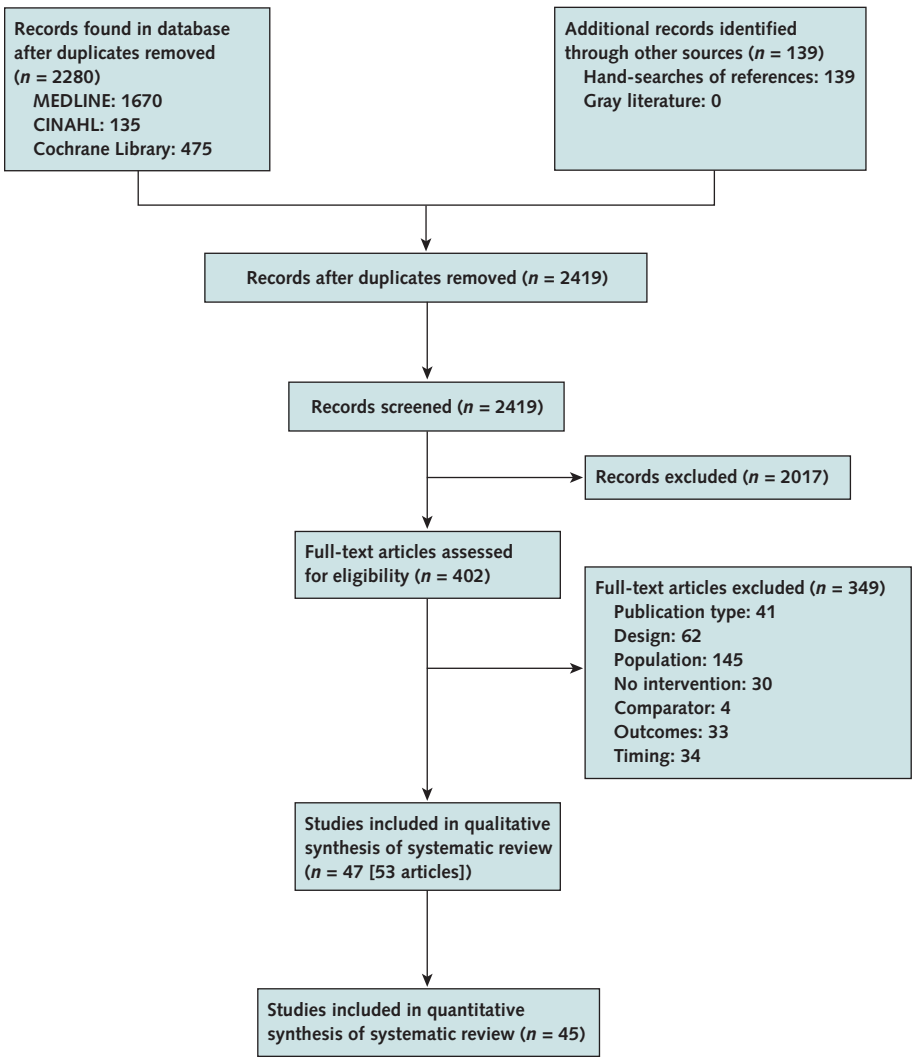
HF = heart failure; KQ = key question; NT-proBNP = *N*-terminal pro–B-type natriuretic peptide; PICOTS = populations, interventions, comparators, outcomes, timing, and setting.

* During data abstraction, we required samples to have been recruited during or within 1 wk of an index hospitalization. If the study authors did not report this clearly, we contacted them to obtain additional information. When we could not verify whether the majority of the sample had been recruited during this period, we excluded the study.

† We did not consider results presented only in figures (e.g., Kaplan–Meier curves) to be eligible for inclusion when the investigators did not clearly report results for an eligible outcome timing (readmission rate ≤6 mo from the index hospitalization).

‡ Eligible quality-of-life and functional status measures included the Minnesota Living With Heart Failure Questionnaire, the Quality of Life Index–Cardiac Version, the Kansas City Cardiomyopathy Questionnaire, the 6-min walk test, change in the New York Heart Association classification from baseline, the Short Form-36, the Short Form-12, and EQ-5D.

Appendix Figure 1. **Summary of evidence search and selection.**



Appendix Table 3. Characteristics of Included Trials

Study, Year (Reference)	Country	Setting	Intervention Group; Participants, *n*	Comparator Group; Participants, *n*	Intensity	Timing, *mo**	Baseline NYHA Class	Mean EF	Age, *y*	Female, %	Nonwhite, %	Medication at Discharge, %	Coexisting Conditions, %	Risk of Bias
Albert et al, 2007 (64)	United States	Single-center	PE; 37	UC; 39	Low	3	–	EF <0.40: 100%	60	23	17	ACEI or ARB: 88 BB: 56	DM: 33 CAD: 66 MI: 45 AF: 37	High
Aldamiz-Echevarría Iraúrgui et al, 2007 (29)	Spain	Single-center	HVP; 137	UC; 142	High	6	–	0.50	76	61	NR	ACEI or ARB: 84 BB: 12	DM: 36 IHD: 30.5 AF: 49.6	Medium
Angermann et al, 2012 (38)	Germany	Multicenter	STS; 352	UC; 363	High	6	III or IV: 40%	0.30	69	29	NR	ACEI or ARB: 88 BB: 80	DM: 36 CAD: 58 AF: 29 COPD: 19	Medium
Barth, 2001 (34)	United States	Single-center	STS; 17	UC; 17	Low	2	NR	NR	75	53	NR	NR	DM: 33 Other CD: 68	High
Benatar et al, 2003 (19)	United States	Multicenter	HVP; 108	TM; 108	Medium	6	Mean: 3.1	0.38	63	63	93	ACEI or ARB: 76 BB: 53	DM: 23 CAD or other CD: 61	Unclear
López Cabezas et al, 2006 (44)	Spain	Multicenter	STS; 70	UC; 64	Medium	2, 6	III or IV: 10%	0.51	75	56	NR	ACEI or ARB: 72 BB: 7	DM: 34 MI: 20	Medium
Dar et al, 2009 (49)	United Kingdom	Multicenter	TM; 91	UC; 91	High	6	–	EF ≥0.40: 39%†	72	34	20 (South Asian)	ACEI or ARB: 88 BB: 56	DM: 36 CAD: 55 Prior MI: 48 COPD: 91	Medium
Davis et al, 2012 (67)	United States	Single-center	CT; 63	UC; 62	Medium	1	III or IV: 53%	0.34	59	53	69	NR	DM: 39 AF: 26 COPD: 22 MCI: 100	Medium
Dendale et al, 2012 (46)	Belgium	Multicenter	TM; 80	UC; 80	Medium	6	Mean: 3.0	LVEF: 0.35	76	35	NR	NR	NR	Unclear
Domingues et al, 2011 (39)	Brazil	Single-center	STS; 48	UC; 63	Low	3	–	LVEF: 0.29	63	32	19	NR	NR	Medium
Ducharme et al, 2005 (59)	Canada	Single-center	CB (MDS-HF); 115	UC; 115	High	6	III or IV: 91%	0.35	69	28	NR	ACEI or ARB: 80 BB: 43	DM: 30 CAD: 66 Prior MI: 50	Low
Duffy et al, 2010 (45)	United States	Multicenter	STS; 15	UC; 17‡	Medium	6	NR	NR	81	59	35§	NR	NR	High
Dunagan et al, 2005 (40)	United States	Single-center	STS; 76	UC; 75	High	6	III or IV: 80%	EF <0.40: 58%	70	56	56	ACEI or ARB: 71 BB: NR	NR	Medium
Ekman et al, 1998 (53)	Sweden	Single-center	CB (nurse-led); 79	UC; 79	Medium	6	Mean: 3.2	0.41‖	80	42	NR	ACEI or ARB: 37 BB: 30	DM: 28 AF: 41 Prior MI: 45	Medium
Goldberg et al, 2003 (48)	United States	Multicenter	TM; 138	UC; 142	High	6	III–IV: 100%	–	59	32	36	ACEI: 74 ARB: 16 BB: 38	DM: 41 MI: 39 AF: 35	Medium
Holland et al, 2007 (32)	United Kingdom	Multicenter	HVP; 148	UC; 143	Medium	6	III or IV: 67%	–	77	36	NR	ACEI or ARB: 77 BB: 39	NR	Medium
Jaarsma et al, 1999 (20)	The Netherlands	Single-center	HVP; 84	UC; 95	Medium	1, 3	III or IV: 100%	LVEF: 0.34	73	42	NR	ACEI or ARB: 70 BB: NR	DM: 30	Medium
Jerant et al, 2001 (18); Jerant et al, 2003 (52)	United States	Single-center	STS; 12 TM; 13	UC; 12	Medium	6	III or IV: 35%	–	70	54	51	ACEI or ARB: 68 BB: 38	IHD: 27	High
Kasper et al, 2002 (57)	United States	Multicenter	CB (MDS-HF); 102	UC; 98	High	6	III: 59% (no patients with class IV)	EF <0.45: 88%	64	40	35	ACEI or ARB: 86 BB: 39	DM: 40	Low
Kimmelstiel et al, 2004 (26)	United States	Multicenter	HVP; 97	UC; 103	Medium	3	II or III: 97%	–	72	42	NR	ACEI or ARB: 92 BB: 57	DM: 48	Medium

Continued on following page

Appendix Table 3—**Continued**

Study, Year (Reference)	Country	Setting	Intervention Group; Participants, *n*	Comparator Group; Participants, *n*	Intensity	Timing, *mo**	Baseline NYHA Class	Mean EF	Age, *y*	Female, %	Nonwhite, %	Medication at Discharge, %	Coexisting Conditions, %	Risk of Bias
Koelling et al, 2005 (62)	United States	Single-center	PE; 107	UC; 116	Low	6	–	0.27	65	42	22	ACEI or alternative: 61 BB: 55	CAD: 64	Low
Kwok et al, 2008 (27)	Hong Kong	Multicenter	HVP; 44	UC; 46	High	6	–	EF <0.40: 24%	78	55	100	ACEI or ARB: 57 BB: 22	DM: 33 IHD: 47 MI: 23 AF: 30 COPD: 10	Medium
Laramee et al, 2003 (37)	United States	Single-center	STS; 141	UC; 146	High	2	III or IV: 35%	–	70	46	NR	ACEI or ARB: 82 BB: 63	DM: 43 Prior MI: 42 IHD: 71	Medium
Linnée and Liedholm, 2006 (63)	Sweden	Multicenter	PE; 122	UC; 108	Low	6	–	EF <0.40: 100%	70	29	NR	ACEI or ARB: 80 BB: 49	NR	Unclear
Liu et al, 2012 (60)	Taiwan	Single-center	CB (MDS-HF); 53	UC; 53	High	6	III or IV: 62%	0.28	61	35	100	ACEI or ARB: 40 BB: 65	DM: 46	Low
McDonald et al, 2001 (54); McDonald et al, 2002 (55); Ledwidge et al, 2003 (56)	Ireland	Single-center	CB (MDS-HF) (51 at 3 mo; 35 at 30 d)¶	UC; (47 at 3 mo; 35 at 30 d)¶	High	1, 3¶	–	EF <0.45: 63%¶	71¶	34¶	NR	ACEI or ARB: 61¶ BB: NR	NR	Unclear
Naylor et al, 2004 (28)	United States	Multicenter	HVP; 118	UC; 121	High	3	–	EF <0.30: 57%	76	57	36	NR	DM: 38 CAD: 49 PD: 30	Low
Nucifora et al, 2006 (65)	Italy	Single-center	PE; 99	UC; 101	Medium	6	III or IV: 65%	–	73	38	NR	ACEI or ARB: 80 BB: 13	DM: 26 IHD: 46 COPD: 27	Medium
Oddone et al, 1999 (61)	United States	Multicenter	CB (primary care); 222	UC; 221	Medium	6	III or IV: 53%	–	65	1	34	ACEI or ARB: 74 BB: 12	NR	Medium
Pekmezaris et al, 2012 (50)	United States	Multicenter	TM; 83	UC; 85**	Medium	1, 3	NR	NR	82	62	9	NR	NR	Medium
Pugh et al, 2001 (25)	United States	Multicenter	HVP; 27	UC; 31	Medium	6	III or IV: 51%	–	74	57	NR	NR	NR	High
Rainville, 1999 (42)	United States	Single-center	STS; 17	UC; 17	Medium	6	III or IV: 85%	–	70	50	NR	ACEI or ARB: 88 BB: 44	NR	Medium
Riegel et al, 2002 (35)	United States	Multicenter	STS; 130	UC; 228	Medium	3, 6	III or IV: 97%	0.43	72	51	NR	ACEI or ARB: 54 BB: 17	DM: 42 CAD: 65 AF: 24 COPD: 36	Medium
Riegel and Carlson, 2004 (66)	United States	Multicenter	PS; 45	UC; 43	Medium	1, 3	III or IV: 64%	0.45	73	58	NR	NR	DM: 46 Prior MI: 35 COPD: 25	High
Riegel et al, 2006 (36)	United States	Multicenter	STS; 69	UC; 65	Medium	1, 3, 6	III or IV: 81%	EF <0.40: 55%	72	54	100	ACEI or ARB: 75 BB: 54	DM: 59 IHD: 44 MI: 28 AF: 17	Medium
Rich et al, 1993 (31)	United States	Single-center	HVP; 63	UC; 35	High	3	Mean: 2.8	–	79	59	50	NR	DM: 31 MI: 23	Medium
Rich et al, 1995 (30)	United States	Single-center	HVP; 142	UC; 140	High	3	Mean: 2.4	0.43	79	63	55	ACEI: 59 BB: 12	DM: 28 MI: 43	Medium
Schwarz et al, 2008 (47)	United States	Single-center	HVP; 142	UC; 51	Medium	3	III or IV: 79%	–	78	52	19	NR	DM: 50 MI: 51 AF: 30 COPD: 29	Medium

Continued on following page

Appendix Table 3—**Continued**

Study, Year (Reference)	Country	Setting	Intervention Group; Participants, *n*	Comparator Group; Participants, *n*	Intensity	Timing, *mo**	Baseline NYHA Class	Mean EF	Age, *y*	Female, %	Nonwhite, %	Medication at Discharge, %	Coexisting Conditions, %	Risk of Bias
Sethares and Elliott, 2004 (21)	United States	Single-center	HVP; 142	UC; 37	Medium	3	Mean: 3	0.40	76	53	8.5	ACEI or ARB: 61 BB: 49	NR	High
Stewart et al, 1998 (24)	Australia	Single-center	HVP; 142	UC; 48	Medium	6	III or IV: 48%	–	75	52	NR	ACEI: 81 BB: NR	DM: 22 IHD: 67 MI: 42 AF: 31	Medium
Stewart et al, 1999 (23)	Australia	Single-center	HVP; 142	UC; 100	Medium	6	III or IV: 56%	0.37	76	38	NR	ACEI or ARB: 71 BB: 28	DM: 34 IHD: 78 AF: 35	Medium
Strömberg et al, 2003 (58)	Sweden	Multicenter	CB (nurse-led); 52	UC; 54	Medium	3	III or IV: 82%	–	78	39	NR	ACEI or ARB: 82 BB: 58	DM: 24 IHD: 68	Low
Thompson et al, 2005 (33)	United Kingdom	Multicenter	HVP; 58	UC; 48	High	6	III or IV: 40%	0.30	73	28	NR	ACEI or ARB: 69 BB: 18	DM: 21 MI: 52 AF: 30 CA: 24	High
Triller and Hamilton, 2007 (22)	United States	Multicenter	HVP; 77	UC††; 77	Medium	6	NR	NR	80	72	7	ACEI or ARB: 47 BB: 62	NR	Unclear
Tsuyuki et al, 2004 (43)	Canada	Multicenter	STS; 140	UC; 136	High	6	III or IV: 37%	0.315	72	20	NR	ACEI or ARB: 85 BB: 43	NR	Medium
Wakefield et al, 2008 (41); Wakefield et al, 2009 (73)	United States	Single-center (VAMC)	STS; 47 VP; 52	UC; 49	Medium	6	III or IV: 72%	0.41	69	1	6	NR	NR	Medium
Woodend et al, 2008 (51)	Canada	Single-center	TM; 62	UC; 59	High	3	III or IV: 62%	–	67	28	NR	NR	Prior MI: 57	High

ACEI = angiotensin-converting enzyme inhibitor; AF = atrial fibrillation; ARB = angiotensin II–receptor blocker; BB = β-blocker; CAD = coronary artery disease; CB = clinic-based; CD = cardiac disorder; COPD = chronic obstructive pulmonary disease; CT = cognitive training; DM = diabetes mellitus; EF = ejection fraction; HF = heart failure; HVP = home-visiting program; IHD = ischemic heart disease; LVEF = left ventricular ejection fraction; MCI = mild cognitive impairment; MDS = multidisciplinary; MI = myocardial infarction; NR = not reported; NYHA = New York Heart Association; PD = pulmonary disease; PE = primarily educational; PS = peer support; STS = structured telephone support; TM = telemonitoring; UC = usual care; VAMC = Veterans Affairs medical center; VP = videophone.

* Timing of readmission outcome.

† From 168 patients (92% of total sample).

‡ Both groups also received home health care co-intervention that included home nursing visits.

§ Authors reported that >35% of participants were members of minority groups but did not provide exact numbers.

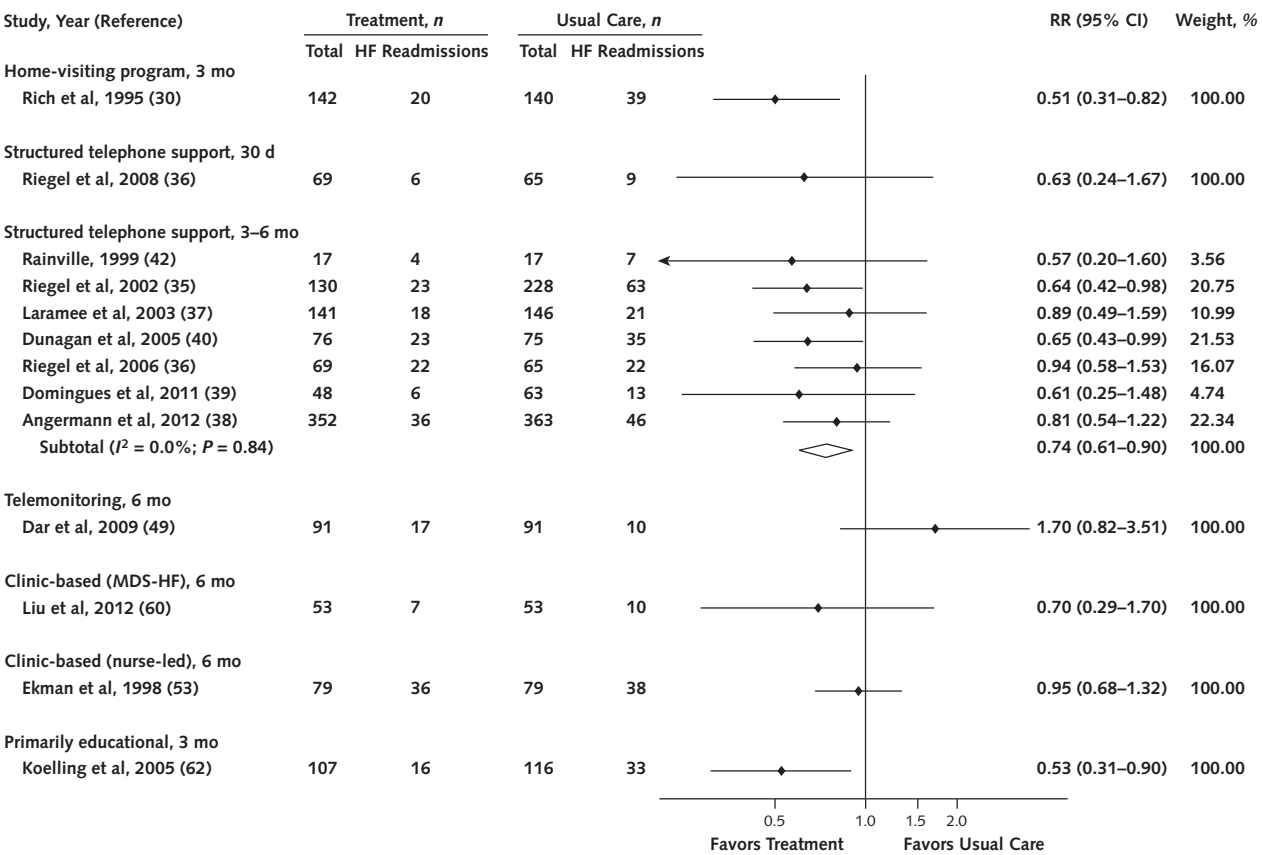
‖ From 99 patients (63% of total sample).

¶ Data are from reference 67; percentages vary slightly from those presented in companion studies (66, 68).

** Both groups received home health care, including home nursing visits (42).

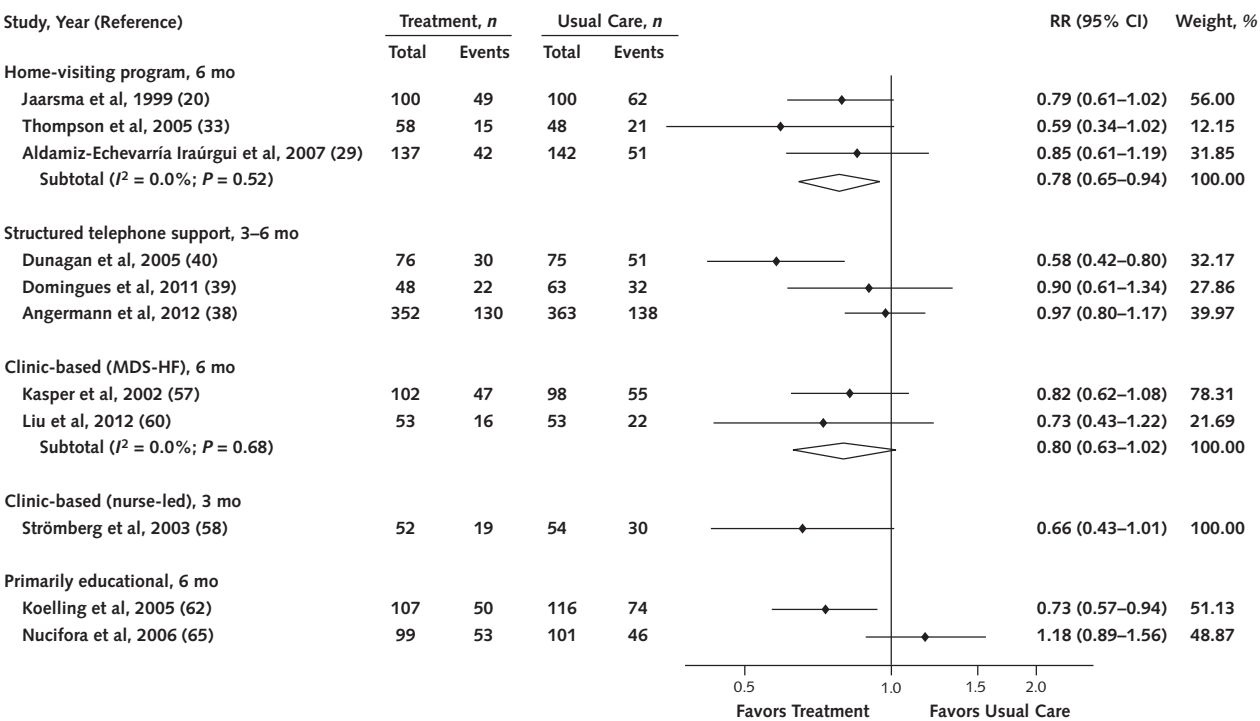
†† Study compared pharmacist home visits among a sample of patients receiving home nursing visits.

Appendix Figure 2. **HF readmissions for transitional care interventions compared with usual care, by intervention category and outcome timing.**



Weights are from random-effects analysis. HF = heart failure; MDS = multidisciplinary; RR = risk ratio.

Appendix Figure 3. **Composite all-cause readmission or mortality for transitional care interventions compared with usual care, by intervention category and outcome timing.**



Weights are from random-effects analysis. MDS-HF = multidisciplinary heart failure; RR = risk ratio.