Original Investigation

Preventing 30-Day Hospital Readmissions
A Systematic Review and Meta-analysis of Randomized Trials

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IMPORTANCE Reducing early (<30 days) hospital readmissions is a policy priority aimed at improving health care quality. The cumulative complexity model conceptualizes patient context. It predicts that highly supportive discharge interventions will enhance patient capacity to enact burdensome self-care and avoid readmissions.

OBJECTIVE To synthesize the evidence of the efficacy of interventions to reduce early hospital readmissions and identify intervention features—including their impact on treatment burden and on patients' capacity to enact postdischarge self-care—that might explain their varying effects.

DATA SOURCES We searched PubMed, Ovid MEDLINE, Ovid EMBASE, EBSCO CINAHL, and Scopus (1990 until April 1, 2013), contacted experts, and reviewed bibliographies.

STUDY SELECTION Randomized trials that assessed the effect of interventions on all-cause or unplanned readmissions within 30 days of discharge in adult patients hospitalized for a medical or surgical cause for more than 24 hours and discharged to home.

DATA EXTRACTION AND SYNTHESIS Reviewer pairs extracted trial characteristics and used an activity-based coding strategy to characterize the interventions; fidelity was confirmed with authors. Blinded to trial outcomes, reviewers noted the extent to which interventions placed additional work on patients after discharge or supported their capacity for self-care in accordance with the cumulative complexity model.

MAIN OUTCOMES AND MEASURES Relative risk of all-cause or unplanned readmission with or without out-of-hospital deaths at 30 days postdischarge.

RESULTS In 42 trials, the tested interventions prevented early readmissions (pooled random-effects relative risk, 0.82 [95% CI, 0.73-0.91]; $P < .001$; $I^2 = 31\%$), a finding that was consistent across patient subgroups. Trials published before 2002 reported interventions that were 1.6 times more effective than those tested later (interaction $P = .01$). In exploratory subgroup analyses, interventions with many components (interaction $P = .001$), involving more individuals in care delivery (interaction $P = .05$), and supporting patient capacity for self-care (interaction $P = .04$) were 1.4, 1.3, and 1.3 times more effective than other interventions, respectively. A post hoc regression model showed incremental value in providing comprehensive, postdischarge support to patients and caregivers.

CONCLUSIONS AND RELEVANCE Tested interventions are effective at reducing readmissions, but more effective interventions are complex and support patient capacity for self-care. Interventions tested more recently are less effective.

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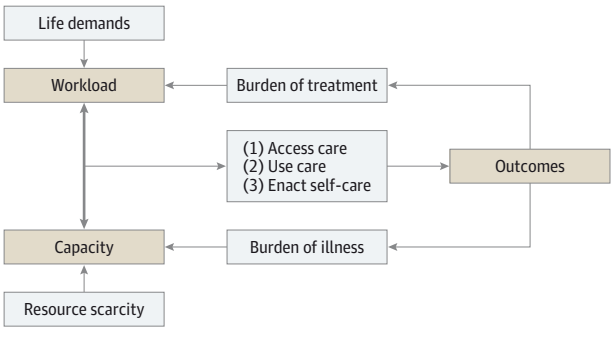
Early hospital readmissions have been recognized as a common and costly occurrence, particularly among elderly and high-risk patients. One in 5 Medicare beneficiaries is readmitted within 30 days, for example, at a cost of more than $26 billion per year.[1] To encourage improvement in the quality of care and a reduction in unnecessary health expense, policymakers, reimbursement strategists, and the US government have made reducing 30-day hospital readmissions a national priority.[2-4] Achieving this goal, however, requires a more complete understanding of the underlying causes of readmission.

The cumulative complexity model (CuCoM)[5] is a framework developed by our research group that conceptualizes patient context as a balance between workload and capacity (**Figure 1**). Workload consists of all the work of being a patient and includes efforts to understand and plan for care, to enroll the support of others, and to access and use health care services.[6,7] Capacity is determined by the quality and availability of resources that patients can mobilize to carry out this work (physical and mental health, social capital, financial resources, and environmental assets). The CuCoM is novel in its consideration of the effects of treatment burden on patient context, and it illustrates how infeasible, unsupported, and context-irreverent care can lead to poor health outcomes and reduced health care effectiveness. Because patients recently discharged from the hospital are in a state of extreme physiologic and psychological vulnerability,[8] their capacity for enacting self-care is low. The CuCoM predicts that, unless sufficient support is given to enhance patient and caregiver capacity to carry out the work of patienthood, placing highly burdensome discharge demands on these patients will lead to poor outcomes and hospital readmission.

To evaluate the validity of the CuCoM and provide hypothesis-generating work in the understanding of patient context, we chose to synthesize the evidence on the efficacy of interventions to reduce early hospital readmissions. In particular, we sought to determine the degree to which a number of intervention characteristics—including their impact on patient capacity and workload—might account for differences in their effectiveness.

Figure 1. The Cumulative Complexity Model



Patient context is represented as a balance between workload and capacity. This balance must be optimized to ensure care effectiveness and improve outcomes. In turn, the outcomes achieved feed back to affect the workload-capacity balance.

Methods

A registered protocol (PROSPERO CRD42013004773) guided the conduct of this review,[9] which we report in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) Statement.[10]

Eligibility Criteria

Eligible studies were randomized trials reported in English or Spanish, since 1990, that assessed the effectiveness of peri-discharge interventions vs any comparator on the risk of early (ie, within 30 days of discharge) all-cause or unplanned readmissions with or without out-of-hospital deaths. The intervention had to focus its efforts on the hospital-to-home transition, permit patients across arms to have otherwise similar inpatient experiences, and be generalizable to contexts beyond a single patient diagnosis. Adult patients had to be admitted from the community to an inpatient ward for at least 24 hours with a medical or surgical cause. Studies including obstetric or psychiatric admissions or only including discharges to skilled nursing or rehabilitation facilities were excluded.

Information Sources

In collaboration with an experienced research librarian (P.J.E.), we searched in April of 2013 the following databases: PubMed, Ovid MEDLINE, Ovid EMBASE, EBSCO CINAHL, and Scopus. The complete search strategy is reported in eAppendix 1 (in Supplement). Two reviewers (T.S. and A.L.L.) hand-searched the bibliographies of included studies and recent reviews. Experts in the field were asked to identify additional references.

Study Selection

Four reviewers (A.L.L., M.R.G., J.P.B., and T.S.) worked independently and considered the eligibility of candidate articles by examining their titles and abstracts, and then the full version of articles identified as potentially eligible by at least 1 reviewer. Conflicts about the eligibility of full articles were resolved by discussion and consensus. Eligibility was delayed for studies reporting outcomes incompletely, pending author contact.

Data Collection

After creating and piloting a standardized form, the reviewers (A.L.L., M.R.G., and J.P.B.), working independently and in duplicate and using a web-based program (DistillerSR), abstracted details about the patient population, the interventions compared, and the outcomes reported.

We abstracted details of the interventions tested verbatim from either the trial report or a cited protocol, limiting our focus to the period of hospitalization until 30 days after discharge, and identifying the "net intervention" by selecting out activities that occurred in the intervention arm but not in the control arm. These activities were coded using a taxonomy adapted from Hansen et al[11] (**Table 1**). We also noted the number of meaningfully involved individuals participating in the

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intervention's delivery and the number of meaningful interactions these individuals had with patients. Meaningfully involved individuals played a structured and requisite function in the delivery of central aspects of the intervention (eg, a physician who might be contacted only as needed would not be considered meaningfully involved). Similarly, meaningful patient interactions were defined as those that were the proposed sources of the intervention's effectiveness (eg, a nurse visiting a patient only to deliver educational materials but not to actually engage in educational activity would not be considered a meaningful interaction). Two team members (A.L.L. and M.R.G.) created summary descriptions of the interventions in a standardized format; these were shared with each author to confirm their fidelity to what happened in the trial.

After calibrating judgments on a pilot sample, 2 raters familiar with the CuCoM (F.S.M. and K.G.), not involved in data collection and blinded to trial results, evaluated each standardized intervention description on a scale of 1 (substantially decrease) to 4 (no effect) to 7 (substantially increase) to reflect the degree to which the intervention was likely to affect patient workload and patient capacity for self-care. The impact on patient capacity was rated with perfect agreement 50% of the time and within 1 point of difference in 42% of cases (8% differed by 2 points). Because no interventions were rated to decrease patient capacity and all mean ratings fell within the range of 4.0 to 5.5, we elected to dichotomize the variable (threshold of ≥5 for increasing capacity) for analysis. Workload was more difficult to assess reliably: perfect agreement and minor disagreement (±1 point) were seen in 29% and 44% of cases, respectively, with 27% of cases differing by 2 or more points. This variable was divided into 3 categories (increase, decrease, no change).

For each included trial, we extracted or computed the risk of early readmission for each arm, analyzing patients as randomized (intention to treat analysis). We used the number randomized as the denominator except when the number of patients discharged was reported and differed from the number randomized. We selected the outcome to extract on the basis of an ad hoc hierarchy of outcomes of interest, with priority given to unplanned readmissions, then to all-cause readmissions, and finally to the composite end points of unplanned and all-cause readmissions plus out-of-hospital deaths, respectively. Outcomes were extracted and analyzed at the longest period of follow-up, up to 30 days from discharge. Examination of trials reporting the effect of interventions on more than 1 of these outcomes revealed that treatment effects were consistent across them (data not shown).

Table 1. Activity-Based Coding Framework for Discharge Interventions

Label	Activity Observed
Discharge planning	Simply thinking about and formalizing an approach to prepare for discharge when this did not occur in any way in the control arm
Case management	Logistical coordination of care and/or resources not specifically focused on self-management and either not occurring in control arm or occurring to lesser degree
Telephone follow-up	Use of a telephone or videophone for provider-initiated communication after discharge that does not occur in the control arm
Telemonitoring	Use of remote technology designed for the patient to transmit objective measures of health status with or without connected subjective assessment
Patient education	Patient-directed education related to diagnosis or treatment rationale but not focused on encouraging self-management and not occurring in control arm
Self-management	Patient-directed education or coaching directly focused on improving patient's ability to self-manage care needs that does not happen in control arm
Medication intervention	Medication reconciliation or special education aimed at improving medication understanding or adherence; often conducted by a pharmacist but need not be
Home visits	Physical visitation by intervention provider to patient's place of residence when this does not happen in control arm
Follow-up scheduled	Scheduling of a follow-up visit prior to discharge when this is not done in the control arm or is done less reliably
Patient-centered discharge instructions	Some difference in the format or usability of discharge materials to make them more accessible or relevant compared with control
Clinician continuity	Increased provider presence on both sides of the hospital-to-home transition compared with control; may include involvement of PCP in inpatient care or strategic follow-up with inpatient clinician after discharge or "bridging" clinician
Timely follow-up	Postdischarge follow-up visit or communication with patient when this either does not occur or occurs at a later date in the control arm
Timely PCP communication	Engagement with PCP in communication about patient status when this either does not occur or occurs at a later date in the control arm
Patient hotline	Presence of an open line for patient-initiated communication when this either does not exist in the control arm or is more restricted in availability or usefulness
Rehabilitation intervention	Patient-directed rehabilitation efforts that are not entirely diagnosis specific but aimed at improving functional status and do not exist in the control arm
Streamlining	A general streamlining of services provided, often with dedicated assignment of responsibility, when this does not occur in the control arm
Making requisite	Increasing the use or quality of services currently available but underutilized compared with the situation in the control arm
Other	Special situations unique to the intervention (eg, caregiver education, peer mentoring)

Abbreviation: PCP, primary care provider.

Risk of Bias

Two raters (A.L.L. and M.K.) worked independently and in duplicate to determine the extent to which each trial was at risk of bias using a standardized form based on the Cochrane Collaboration's tool.[12] The assessment considered the quality of the randomization sequence generation, allocation concealment, blinding of outcome assessors, the potential for missing outcomes (ie, likelihood of missing readmissions to other hospitals), and the proportion of patients lost to follow-up. For missing outcomes, "high risk of bias" was assigned when the readmissions data came from internal health system records only. To assess for publication bias, we examined a funnel plot for asymmetry and conducted asymmetry regression according to Sterne and Egger[13] and determined the associated *P* value.

Data Synthesis

We used random-effects meta-analyses to estimate pooled risk ratios and 95% confidence intervals for early readmission.[14,15] We tested for heterogeneity of effect on this outcome using the Cochran Q χ^2 test[16] and estimated between-trial inconsistency not due to chance using the I^2 statistic.[17]

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To explore the effects of patient, intervention, and outcome characteristics on the impact of measured intervention effectiveness, we conducted planned subgroup analyses, testing variables 1 at a time.

Patient characteristics tested were age (mean ≥65 years or not), diagnosis (heart failure or other), and hospital ward (general medical or other). Intervention characteristics tested included the number of unique activities involved in the intervention, the number of unique individuals or roles meaningfully involved in its delivery, the minimum number of meaningful patient interactions occurring within 30 days, the location of the intervention activity (ie, whether it occurred entirely during the inpatient stay, after discharge, or as a combination that "bridged" the transition), whether the intervention was rated to increase or decrease patient workload, and whether the intervention was rated to increase patient capacity (no intervention was found that decreased patient capacity for self-care). Ad hoc variables tested were year of publication and type of outcome reported (ie, unplanned readmissions vs other).

Informed by the findings of the exploratory subgroup analyses and our initial hypotheses, we constructed a post hoc metaregression model to test a variable that reflected the degree to which discharge interventions provided comprehensive patient and caregiver support. This "comprehensive support" variable could return values within a range of 0 to 4 "points" on the basis of whether the intervention (1) was rated to increase patient capacity, (2) had at least 5 (75th percentile of distribution) unique intervention activities, (3) had at least 5 (75th percentile of distribution) meaningful patient contacts, and (4) had at least 2 (75th percentile of distribution) individuals involved in its delivery. We created 3 categories for this variable: interventions with zero points (category 1), interventions with 1 or 2 points (category 2), and interventions with 3 or 4 points (category 3). To control for changes in standard care delivery over time, we adjusted on the basis of the year of publication variable.

Results

Study Selection

Our initial database search generated 1128 reports (eFigure 1 in Supplement). Through abstract and title screening, 256 reports were identified for full-text review. During full-text screening (agreement, 89%), 24 were selected for inclusion and 39 were set aside for author contact prior to making a decision. Of 7 potentially eligible studies identified from bibliographies and expert consultation, 2 were included and 1 was set aside for author contact. Of the 40 trials requiring author contact for a final eligibility decision, 21 were deemed eligible. Of the 48 apparently eligible trials, 1 was found ineligible after the author confirmed that readmission data were collected only for readmissions related to the index diagnosis.[18] The final sample therefore comprised 47 trials from 46 reports.[19-64]

Of the 47 eligible trials, 42 contributed data for the primary meta-analysis, and 5 (those that reported numbers of readmissions rather than the number of patients readmitted) were analyzed separately.[31,45,50,55,61] A complete list of excluded full-text studies with rationale for exclusion is available in eAppendix 2 (in Supplement).

Study Characteristics

Table 2 describes the included trials. Many were single-center trials taking place in academic medical centers, enrolling few patients (eg, 22 trials enrolled <200 patients), and reporting 30-day readmissions. Most interventions tested took place in both the inpatient and outpatient settings. The coded activity analysis is reported in eTable 1 (in Supplement). In general, interventions included anywhere from 1 to 7 unique activities. Case management, patient education, home visits, and self-management support were commonly present in net activity descriptions (eTable 1 in Supplement). Trial authors responded to confirmation requests for 34 of the 47 net intervention descriptions. Three authors requested minor modifications and 1 author made major modifications to these descriptions.

Most studies were at low risk of bias (eTable 2 and eFigure 2 in Supplement). The most common methodological limitation of these trials was the lack of a reliable method for dealing with missing data.

Meta-analysis

In the 42 trials reporting readmission rates, the overall pooled relative risk (RR) of readmission within 30 days was 0.82 (95% CI, 0.73-0.91; $P < .001$) (**Figure 2**). Inconsistency across trials was low ($I^2 = 31\%$). Funnel plot examination showed asymmetry suggestive of publication bias in the context of smaller studies (eFigure 3 in Supplement), and the Egger test was significant ($P = .02$). The 5 trials reporting number of readmissions (rather than number of patients with readmissions) had a pooled relative risk of readmission of 0.93 (95% CI, 0.72-1.20; $I^2 = 23\%$; $P = .59$). Although this result was consistent with the risk found in trials reporting readmission rates (interaction $P = .38$), we opted not to include these trials in subgroup analyses.

Subgroup analyses failed to find an interaction between trial results and patient characteristics or outcome measured (**Table 3**). A number of intervention characteristics, however, did interact with measured effectiveness. These include whether the intervention was rated to augment patient capacity for self-care (RR, 0.68 [95% CI, 0.53-0.86] when it was and RR, 0.88 [95% CI, 0.80-0.97] when it was not; interaction $P = .04$), whether the intervention had at least 5 unique, component activities (RR, 0.63 [95% CI, 0.53-0.76] when it did and RR, 0.91 [95% CI, 0.81-1.01] when it did not; interaction $P = .001$), and whether the intervention had at least 2 individuals involved in delivery (RR, 0.69 [95% CI, 0.57-0.84] when it did and RR, 0.87 [95% CI, 0.77-0.98] when it did not; interaction $P = .05$). Studies testing interventions more recently were associated with reduced effectiveness (RR, 0.89 [95% CI, 0.81-0.97] when published in 2002 or later and RR, 0.56 [95% CI, 0.40-0.79] when published prior to 2002; interaction $P = .01$). Other characteristics of the interventions, such as their rated effect on patient workload and the site of delivery, had no significant interaction with the intervention effect.

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Table 2. Study Characteristics[a]

Source	Setting	Population	Added Intervention Program	Baseline Control Activity	Outcome Time Reported	Patients Discharged, No.	Activities[b]/ People[c]/ Interactions[d] Included in Intervention, No.	Capacity[e]	Workload[f]	Location[g]
Melton et al,[19] 2012	48 US states	Commercially insured for 3 acute DRGs	Risk-prioritized telephone follow-up	Nonprioritized telephone follow-up	UR, 1 mo	3988	1/1/1	4.0	3.5	OP
Marusic et al,[20] 2013	Academic hospital in Croatia	Elderly patients receiving ≥2 medications for chronic disease	Specialized pharmacotherapeutic counseling	Standard discharge planning and usual information about drugs from physician	UR, 1 mo	160	2/1/1	4.0	3.5	IP
Altfeld et al,[21] 2012	US	Elderly patients receiving ≥7 medications with psychosocial need	Targeted telephone follow-up program	Standard discharge planning without any follow-up contact	ACR, 1 mo	906	2/1/1	5.0	2.0	OP
Davis et al,[22] 2012	Academic center, US	Patients with HF with mild cognitive impairment	Self-management focused education program	Standard discharge HF teaching and booklet	ACR, 1 mo	125	5/1/2	5.0	3.5	Both
Bowles et al,[23] 2011	Urban community, US	Mostly black patients with HF under specific home care agency	Telehomecare substitution of traditional home care	Clinical pathway for HF and home care	ACR, 1 mo	218	1/2/5	4.0	5.5	OP
Finn et al,[24] 2011[h]	Academic center, US	General medical patients of academic center; approximately 25% discharged to SNF	Embedded nurse practitioner into academic team to improve discharge process	Standard discharge planning with follow-up scheduled by resident	ACR, 1 mo	646	2/1/1	4.0	2.5	IP
Wong et al,[25] 2011	Large general hospital, Hong Kong	Elderly general medical population	Use of nurse case managers and trained volunteers to improve transition through health-social partnership	Usual discharge planning for follow-up and support	ACR, 1 mo	686	4/3/5	4.5	3.5	Both
Leventhal et al,[26] 2011	University hospital, Switzerland	Elderly patients with HF	Outpatient, interdisciplinary education and support program	Standard care with HF consultation, education booklet	ACR, 1 mo	34	5/1/4	4.5	4.0	OP
Rytter et al,[27] 2010	Single center, Denmark	Elderly patients from medical or geriatric ward	Use of mandatory home visits to improve follow-up from PCP and district nurses	Standard discharge procedures and letters	ACR, 1 mo	331	4/2/2	4.0	2.5	OP
Koehler et al,[28] 2009	Academic center, US	Elderly general medical patients expected to return to home or assisted living	Supplemental care bundle that shifted responsibilities from nurses to care coordinators and added follow-up	Nursing staff do medication reconciliation, discharge medication teaching, and education; pharmacist review	UR, 1 mo	41	6/2/5	4.5	4.0	Both
Braun,[29] 2009	Medical center, Israel	General medical patients	Use of tight telephone follow-up, especially to improve adherence	Standard discharge planning and summary	ACR, 1 mo	400	1/1/2	4.5	3.0	OP
Courtney et al,[30] 2009	Tertiary center, Australia	Elderly general medical patients at high risk	Individualized, exercise-based care plan for elderly	Routine discharge and rehabilitation advice, planning	UR, 1 mo	128	6/2/5	5.0	5.0	Both
Jack et al,[31] 2009	Academic, urban, safety net center, US	General medical patients; 51% black	Standardized discharge package to minimize failures using discharge planners and pharmacists	Similar to intervention but uncoordinated	ACRE, 1 mo	738	6/2/3	5.0	2.5	Both

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Table 2. Study Characteristics[a] (continued)

Source	Setting	Population	Added Intervention Program	Baseline Control Activity	Outcome Time Reported	Patients Discharged, No.	Activities[b]/ People[c]/ Interactions[d] Included in Intervention, No.	Capacity[e]	Workload[f]	Location[g]
Wakefield et al,[32] 2008	VA medical center, Iowa, US	Men with HF; mean age, 69 y	Telehealth-facilitated postdischarge support program	Usual discharge teaching and follow-up	ACR, 1 mo	148	2/1/5	5.0	5.0	OP
Balaban et al,[33] 2008	Small community teaching hospital, US	Culturally and linguistically diverse general medical or surgical patients	Program to promptly reconnect patients to medical home through discharge form	Standard discharge planning and instruction	ACR, 1 mo	96	3/2/2	5.0	2.5	Both
Wong et al,[34] 2008	3 Regional hospitals, Hong Kong	Elderly patients readmitted to department of medicine	Preventive, postdischarge home visits for high-risk patients	Standard discharge planning and instruction	UR, 1 mo	354	2/1/2	4.0	4.0	Both
Coleman et al,[35] 2006	Single center, US	Elderly medical patients who were in capitated delivery system; approximately 20% discharged to SNF	Use of transition coaches and personal health record to equip patients and caregivers to be more active in care	Not well reported	UR, 1 mo	750	5/1/5	4.5	5.0	Both
Linne et al,[36] 2006	Multiple community hospitals, Sweden	Patients with HF; discharge disposition not reported	Use computer-based education session in discharge process	Standard HF education and materials	ACR, 1 mo	230	2/0/0	4.0	4.5	Both
Casas et al,[37] 2006	2 Tertiary centers, 1 in Spain and 1 in Belgium	Elderly patients with COPD	Integrated care plan to generate synergy and avoid redundancy between inpatient and outpatient care teams for patients with COPD	Standard discharge protocol without support of nurse or call center	ACR, 1 mo	155	7/3/5	5.0	4.5	Both
Riegel et al,[38] 2006	2 Community hospitals, southern California, US	Mexican Americans with HF who were old, ill, and poorly acculturated	Telephone case management program to improve discharge transition in Mexican Americans	Nonstandardized, HF education often in English	ACR, 1 mo	135	5/1/1	5.5	3.0	OP
Koelling et al,[39] 2005	University hospital, US	Selected patients with HF; mean age, 65 y	Single predischarge education session	Standard discharge information and education, booklet	ACR, 1 mo	223	2/1/1	4.5	4.5	IP
Mejhert et al,[40] 2004	University hospital, Sweden	Elderly patients with HF	Nurse-driven, protocol-based outpatient management program	Standard discharge care; usual follow-up	ACR+D, 1 mo	196	3/2/1	5.0	4.5	OP
Kwok et al,[41] 2004	2 Acute hospitals, Hong Kong	Elderly patients with chronic lung disease at high risk	Community nurse-supported program based on weekly home visits	Standard follow-up with home visits as needed	UR, 1 mo	157	4/1/5	5.5	4.5	Both
Doughty et al,[42] 2002[h]	Single center, New Zealand	Patients with HF; dispositions not reported	Outpatient, integrated management program for HF	Usual care under PCP	ACR, 1 mo	197	6/3/1	4.5	5.0	OP
Jaarsma et al,[43] 1999	University Hospital, Netherlands	Elderly patients with HF; mean age, 73 y	Nurse-led education and support program with follow-up home visit	Usual care; no structured education, follow-up call, or home visit	ACR, 1 mo	179	3/1/3	4.0	3.5	Both
Naylor et al,[44] 1999	2 Urban academic hospitals, US	Elderly medical and surgical patients; 45% black	Advanced practice nurse-directed program that stressed continuity, home and telephone follow-up	Routine discharge planning and home care	ACR, 1 mo	363	5/1/4	5.5	2.5	Both
Stewart et al,[45] 1998	Tertiary referral center, Australia	General medical and surgical patients; 83% considered high risk	Risk-targeted, home-based intervention by nurse and pharmacist	Discharge planning with follow-up within 2 wk	UR+DE, 1 mo	762	5/2/3	5.0	2.5	Both

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Table 2. Study Characteristics[a] (continued)

Source	Setting	Population	Added Intervention Program	Baseline Control Activity	Outcome Time Reported	Patients Discharged, No.	Activities[b]/ People[c]/ Interactions[d] Included in Intervention, No.	Capacity[e]	Workload[f]	Location[g]
Dunn et al,[46] 1995	Geriatric hospital, England	Geriatric ward patients; mean age, 83 y	Single home visit from public health nurse	Usual discharge process	ACR, 1 mo	204	2/1/1	4.5	3.0	OP
Rich et al,[47] 1995	Single academic center, US	High-risk, elderly patients with HF	Nurse-directed, multidisciplinary intervention with home visit follow-up	Conventional care by PCP	ACR, 1 mo	274	6/4/5	5.5	2.0	Both
Naylor et al,[48] 1994	Single university hospital, US	Elderly patients with or without caregiver for medical cardiac diagnosis	Individualized, comprehensive program directed by clinical nurse specialists, including home follow-up	Robust but not individualized routine discharge plan	ACR, 2 wk	142	5/1/4	4.5	2.0	Both
Naylor et al,[48] 1994	Single university hospital, US	Elderly patients with or without caregiver for surgical cardiac diagnosis	Individualized, comprehensive program directed by clinical nurse specialists, including home follow-up	Robust but not individualized routine discharge plan	ACR, 2 wk	134	5/1/4	4.5	2.0	Both
Naylor et al,[49] 1990	Urban medical center, US	Elderly general medical or surgical patients	Comprehensive, individualized discharge planning protocol with home follow-up directed by nurse specialists	Nurse-directed routine discharge planning	ACR, 2 wk	40	4/1/4	4.0	3.0	Both
Kulshreshtha et al,[50] 2010	Urban teaching hospital, US	Patients with HF; could enter study up to 2 weeks after discharge	Remote monitoring follow-up program for ambulatory patients	Not well described	ACRE, 1 mo	150	2/1/5	5.5	5.5	OP
Graumlich et al,[51] 2009[h]	Tertiary teaching hospital, US	General medical patients at high risk of readmission	Discharge software to improve communication and address deficiencies	Usual care with handwritten discharge forms	ACR, 1 mo	631	3/1/0	4.0	3.0	IP
Atienza et al,[52] 2004	3 Tertiary university hospitals, Spain	Patients with HF; mean age, 68 y	Hospital discharge and outpatient disease management program	Variable and nonstructured; PCP follow-up	ACR, 1 mo	338	5/2/2	4.5	4.0	Both
Riegel et al,[53] 2004	2 Hospitals in suburban Southwest, US	Patients with HF in integrated health system; mean age, 73 y	Use of peer mentors to improve self-care in recently discharged patients	Inpatient HF education; support groups available	ACR, 1 mo	88	1/1/2	4.5	3.0	OP
Stowasser et al,[54] 2002	2 Large hospitals, Australia	General medical and surgical patients	Medication liaison service to improve communication of medication-related issues through discharge process	Routine care and pharmacist medication review, discharge planning	UR, 1 mo	240	3/1/0	4.0	3.0	IP
Li et al,[55] 2012	Academic center, New York, US	Elderly patients and their family caregivers	Training of family caregivers to prepare for anticipated postdischarge role	Routine care with practical information given to caregivers	ACRE, 2 wk	407	1/0/0	4.5	3.5	IP
Shyu et al,[56] 2005	Large, single center, Taiwan	Elderly patients with hip fracture	Interdisciplinary program of geriatric consultation, rehab, and discharge planning service	Routine care and inpatient physical therapy without home visits	ACR, 1 mo	137	4/3/5	5.5	3.5	Both
Angermann et al,[57] 2012	9 Centers, Germany	Patients with HF; mean age, 69 y	Nurse-coordinated disease management program that emphasized a "call and care center"	Standard discharge planning and follow-up	ACR, 1 mo	715	4/1/5	4.5	4.5	Both
Naylor et al,[58] 2004	6 Academic and community hospitals, US	Elderly patients with HF; 36% black	Advanced practice nurse-directed care program with emphasis on comorbid and chronic condition management; included home follow-up	Standard, site-specific HF discharge planning and follow-up	ACR+D, 1 mo	239	6/1/5	5.0	3.0	Both

(continued)

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Table 2. Study Characteristics[a] (continued)

Source	Setting	Population	Added Intervention Program	Baseline Control Activity	Outcome Time Reported	Patients Discharged, No.	Activities[b]/ People[c]/ Interactions[d] Included in Intervention, No.	Capacity[e]	Workload[f]	Location[g]
Stromberg et al,[59] 2003	1 University and 2 county hospitals, Sweden	Elderly patients with HF	Requisite follow-up in specialized, protocol-driven, nurse-led HF clinic	Conventional primary care follow-up	ACR+D, 1 mo	106	5/1/1	5.0	3.5	OP
Hansen et al,[60] 1995	University hospital, Denmark	Highly selected patients from subacute geriatric ward needing home rehabilitation and medical and social support	Home visit follow-up program for highly targeted elderly population	Discharge summary sent and standard support arranged	ACR, 1 mo	193	4/2/2	5.0	3.5	OP
Maslove et al,[61] 2009[h]	Single academic center, Canada	General medical patients; approximately 80% discharged home	Development of more useful and standardized discharge summary	Standard, attending physician–generated discharge summaries and planning	ACRE, 1 mo	209	2/1/0	4.0	3.5	IP
Forster et al,[62] 2005	2 Campuses of a teaching hospital, Canada	General medical patients; mean age, 66 y	Integration of dedicated clinical nurse specialist into care team to facilitate discharge planning process	Regular discharge care planning	ACR+D, 1 mo	361	3/1/1	4.0	3.0	Both
Dudas et al,[63] 2001	Single academic center, US	General medical service patients	Pharmacy service follow-up call	Regular pharmacy-facilitated discharge process	ACR, 1 mo	221	2/1/1	4.0	3.0	OP
Parry et al,[64] 2009	2 Community hospitals, US	Fee-for-service Medicare patients in single health system; inclusion criteria desired to catch patients discharging to SNF—did not report dispositions	Use of transition coaches and personal health record to equip patients and caregivers to assert more active role in care transition	Not well reported	UR, 1 mo	98	5/1/5	5.0	2.5	Both

Abbreviations: ACR, all-cause readmission rate; ACR+D, all-cause readmission and out-of-hospital death rate; ACRE, all-cause readmission event count; Both, activity occurred in both inpatient and outpatient environments; COPD, chronic obstructive pulmonary disease; DRG, diagnosis-related group; HF, heart failure; IP, all activity occurred in inpatient environment; OP, all activity occurred in outpatient environment; SNF, skilled nursing facility; UR, unplanned readmission rate; UR+DE, unplanned readmission and out-of-hospital deaths event count; US, United States; VA, Veterans Affairs.

[a] Intervention and baseline/control activities were systematically coded in greater detail than can be expressed in this table (see eTable 1 in Supplement).

[b] Number of activities in the intervention as evaluated by coding strategy from Table 1.

[c] Number of individuals meaningfully involved in delivery of the intervention.

[d] Minimum number of meaningful human interactions in intervention delivery.

[e] Rated likelihood of intervention to affect patient capacity for self-care on a scale of 1 (substantially decrease) to 4 (no effect) to 7 (substantially increase).

[f] Rated likelihood of intervention to impose work or burden on patient on a scale of 1 (substantially decrease) to 4 (no effect) to 7 (substantially increase).

[g] Setting (inpatient, outpatient, or both) where intervention activity occurred.

[h] Cluster-randomized study.

Post Hoc Metaregression Analysis

Despite potential colinearity of the contributing variables, metaregression showed a significant and incremental effect of "comprehensive support" on reducing readmissions (**Table 4**). Category 3 comprised 7 interventions.[28,30,37,47,56,58,64] Compared with category 1 interventions, these were associated with a relative risk of readmission of 0.63 (95% CI, 0.43-0.91; P = .02). Category 3 interventions used a consistent and complex strategy that emphasized the assessment and addressing of factors related to patient context and capacity for self-care (including the impact of comorbidities, functional status, caregiver capabilities, socioeconomic factors, potential for self-management, and patient and caregiver goals for care). These interventions coordinated care across the inpatient-to-outpatient transition and involved multiple patient interactions; all but 1[28] involved patient home visits.

Discussion

Our Findings

The body of randomized trial evidence shows a consistent and beneficial effect of tested interventions on the risk of 30-day readmissions. Exploratory subgroup analyses suggest that ef-

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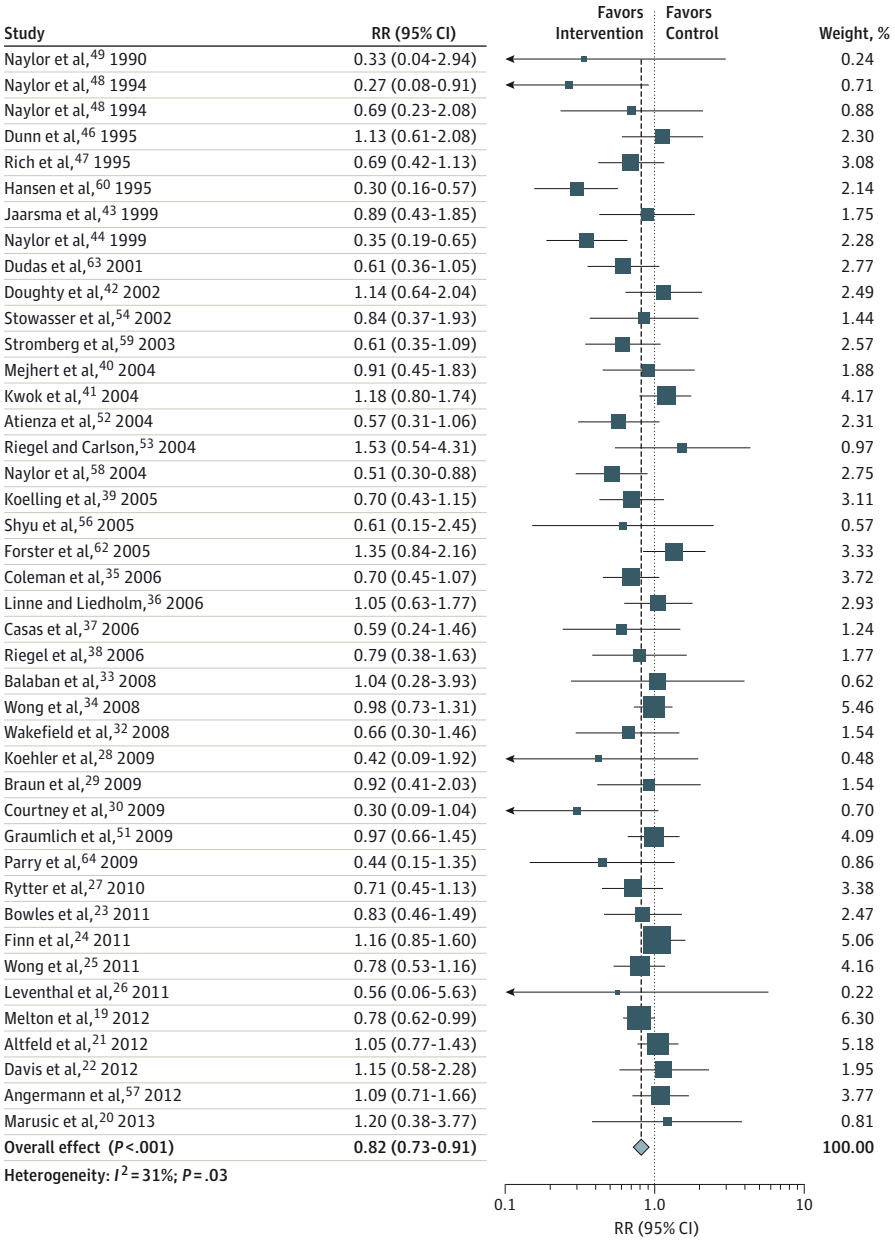
Figure 2. Results of Primary Meta-analysis



Size of the data marker corresponds to the relative weight assigned in the pooled analysis using random-effects models. RR indicates relative risk.

fective interventions are more complex and seek to enhance patient capacity to reliably access and enact postdischarge care. In addition, interventions tested more recently are, in general, less efficacious when compared with controls.

Our findings are consistent with the CuCoM in their suggestion that providing comprehensive and context-sensitive support to patients reduces the risk of early hospital readmission; however, we could not identify an effect of rated intervention workload on this risk.

Limitations and Strengths of This Review

Many studies in this review were conducted in single, academic centers; this raises questions about applicability. Also, the scales that we used to evaluate intervention effects on patient workload and capacity relied on global judgments (rather than criterion-based judgments) and are original to this work. To our knowledge, no validated scale exists to assess the potential of an intervention to impose patient workload or treatment burden and/or affect a patient's capacity for self-care. Although our raters were consistent in their assessments of interventions' effect on patient capacity, their judgment of impact on patient workload was less reliable. Particularly, raters believed that some burdensome interventions could be beneficial if the patient had the capacity and resources to access and enact the care. Because the experience of treatment burden is not constant between patients, an ideal analysis of its

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Table 3. Subgroup Analyses

Study Subgroup Characteristic (No. of Studies in Subgroup)[a]	Readmission, Relative Risk (95% CI)		*P* Value for Interaction
	Subgroup	Comparison Group	
Patient characteristics			
HF (16)	0.82 (0.70-0.95)	0.80 (0.69-0.93)	.83
Age >65 y (36)	0.79 (0.69-0.90)	0.91 (0.74-1.10)	.24
From general medical ward (18)	0.80 (0.67-0.95)	0.83 (0.72-0.95)	.79
Intervention characteristics			
Rated to increase patient capacity (16)	0.68 (0.53-0.86)	0.88 (0.80-0.97)	.04
Rated to increase patient workload (5)[b]	0.77 (0.57-1.03)	0.82 (0.71-0.96)	.68
Rated to decrease patient workload (19)[b]	0.81 (0.67-0.98)	0.82 (0.71-0.96)	.90
Delivered by 2 or more individuals (13)[c]	0.69 (0.57-0.84)	0.87 (0.77-0.98)	.05
Involved ≥5 meaningful patient interactions (13)[c]	0.77 (0.64-0.92)	0.84 (0.73-0.96)	.43
Comprised ≥5 unique activities (16)[c]	0.63 (0.53-0.76)	0.91 (0.81-1.01)	.001
Had both an inpatient and outpatient component (22)	0.78 (0.65-0.92)	0.84 (0.74-0.97)	.46
Study published 2002 or later (33)[d]	0.89 (0.81-0.97)	0.56 (0.40-0.79)	.01
Outcome characteristics			
Outcome measured was unplanned readmissions (9)	0.84 (0.69-1.02)	0.80 (0.70-0.91)	.70

Abbreviation: HF, heart failure.

[a] Compared with the remainder of analyzed studies (ie, 42 − N) unless otherwise noted.

[b] Compared with "no change" (n = 18).

[c] Cutoffs chosen because they represented the 75th percentile of distribution of each variable.

[d] Cutoff chosen because it represented the mid-point of study eligibility for this review.

Table 4. Effects of Comprehensive Support in Metaregression Analysis

Study Characteristic	Studies, No.	Readmission, Relative Risk (95% CI)[a]	*P* Value
Comprehensive support category[b]			
1 (0 points)	15	1 [Reference]	
2 (1 or 2 points)	20	0.82 (0.66-1.02)	.07
3 (3 or 4 points)	7	0.63 (0.43-0.91)	.02
Publication in 2002 or after	33	1.47 (1.10-1.96)	.01

[a] This represents the adjusted effect of each characteristic on early readmission in metaregression.

[b] The comprehensive support variable returned 1 point each for interventions that (1) were rated to increase patient capacity, (2) had ≥5 unique intervention activities, (3) had ≥5 meaningful patient interactions, and (4) had ≥2 individuals involved in its delivery.

effects would be based on patient-reported assessments of intervention workload. Indeed, many eligible patients declined enrollment into some studies,[23,28,44,50,53] often because they did not wish to take on the perceived burden of the intervention; evaluating the effect of intervention-imposed workload in such samples is of limited applicability. In general, these assessments should be regarded as hypothesis-generating and the inferences made on the basis of subgroup analyses must be viewed as tentative (given the potential for chance findings from testing multiple hypotheses and the possibility that some variables are correlated). Finally, despite robust efforts to obtain unpublished data, there was evidence of publication bias. The overall effect of this on our findings is not known.

This review also has many strengths. First, it provides, to our knowledge, the largest and most comprehensive assessment of discharge interventions and their effect on 30-day readmissions, including 47 randomized trials at low risk of bias. This is a stronger and less heterogeneous body of evidence than previously assembled,[11,65] and it includes unpublished data from 18 trials. Our study used an activity-based coding method designed to ensure appropriate characterization of each intervention and the net difference in activity between intervention and control arms. This method contributes to the field and can be applied to future assessments of complex interventions. To our knowledge, this is also the first use of the CuCoM[5] to analyze the impact of health care delivery interventions on patients as an explanation for their relative efficacy.

Comparison With Other Studies

We identified 31 more randomized clinical trials than were accumulated in the most recent review of discharge intervention effects on 30-day readmission rates,[11] and we provide the first meta-analysis on this topic. Although previous studies and reviews have suggested that "bundled" interventions are of greater value,[11,65] this meta-analysis provides objective support for this claim. In addition, our study adds to and enhances the body of evidence related to the importance of patient contextual factors in affecting health outcomes.[66]

Implications for Policy and Practice

In this analysis, interventions that used a complex and supportive strategy to assess and address contextual issues and limitations in patient capacity were most effective at reduc-

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ing early hospital readmissions. Many of these contacted the patient frequently, used home visits, and reported cost savings. This information can be used to guide the design and testing of future interventions. The CuCoM may also have value in helping to conceptualize the effects of health care interventions across diverse patient contexts, but we were unable to characterize a consistent effect of rated intervention workload on outcomes. Finally, we found that more recently tested interventions were less effective. We hypothesize that this may represent (1) a general improvement over time in the standard of care that was not fully appreciated in control descriptions, (2) an increased effort over time to test simpler and less comprehensive interventions, (3) a higher likelihood over time of more diverse interventions to measure and report 30-day readmission rates (eg, including those less focused on reducing early readmissions), and/or (4) a general shift away from interventions stressing human interaction toward those more high tech in nature. Additional study is needed to determine the implications of this finding.

Conclusions

Our results suggest that most interventions tested are effective in reducing the risk of early readmissions. Some features, however, may enhance the effect of these programs. In particular, we found value in interventions that supported patients' capacity for self-care in their transition from hospital to home. Future work intended to improve the effectiveness of health care delivery may benefit from consideration of the demands that health care interventions place on recently discharged patients and their caregivers and the extent to which these demands are offset by comprehensive support for implementation.

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