

REVIEWS

Interventions aimed at addressing unplanned hospital readmissions in the U.S.: A systematic review

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ABSTRACT

One of the policy mechanisms aimed at improving population health through health care delivery is the Hospital Readmissions Reduction Program (HRRP) as outlined in the Affordable Care Act. Although numerous procedural and behavioral interventions have been implemented, the empirical evidence of the efficacy of these interventions is mixed and specific to certain patient segments. This review aimed to systematically assess studies of hospital interventions to reduce 30-day readmissions for specific diseases and populations. Following the PRISMA review checklist, searches were conducted from January 2000 to August 2018 in the MEDLINE and EMBASE databases using terms such as “patient readmission”, “readmit” and “re-hospitalization” in conjunction with disease terms such as “asthma”, “chronic obstructive pulmonary disease (COPD)” and “pneumonia”. Of 3,806 articles identified, 45 were included after a 3-step inclusion process. The age group most frequently considered among the studies was the 65 age cohort. Multidisciplinary collaborative interventions were most frequently effective for the subset of elderly, female, Caucasian, and heart failure patients. Interventions involving patient or family education delivered before and after care were most effective for racial minority, elderly, COPD, and heart failure patients. Telephone follow-up, tele-homecare, and medication reconciliation were largely found to be successful in reducing readmissions. Major gaps exist in identifying successful interventions for reducing 30-day readmissions among patients who sought treatment for sepsis, stroke, and replacement of the hip or knee. Our findings indicate an opportunity for researchers to further study, and for healthcare organizations to implement, more well-informed interventional strategies to reduce readmissions.

Key Words: Hospital readmission, Interventions, Population, Systematic review

1. INTRODUCTION

Unplanned hospital readmissions render implications for population health, as they are generally thought of as indicators of substandard health care delivery quality,^[1] and are often associated with adverse patient outcomes.^[2] Moreover, unplanned readmissions occur at a great cost to private and public insurers in the U.S., with estimations in 2011 that Medicaid, private insurance, and Medicare paid 18%, 20%,

and 58% of all readmission-associated costs in the U.S. respectively.^[3] To address patient safety and quality concerns, and to empower more informed health care decision-making on the part of patients, the Centers for Medicare and Medicaid Services (CMS) began publicly reporting 30-day readmission rates for heart failure, myocardial infarction, and pneumonia in 2010.^[4] In response to the economic burden of hospital readmissions, policymakers incorporated the es-

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establishment of the CMS Hospital Readmissions Reduction Program (HRRP) into the Affordable Care Act as a means of incentivizing hospitals to engage in efforts that would reduce preventable readmissions.^[5-8] Starting in October 2012, CMS was empowered to impose financial penalties on hospitals with higher-than-expected readmissions for the same conditions that the agency began publicly reporting on in 2010.^[8] Since then, CMS has expanded the applicable conditions to include chronic obstructive pulmonary disease (COPD), total hip arthroplasty (THA), total knee arthroplasty (TKA), and coronary artery bypass graft (CABG).

Numerous procedural and behavioral interventions have been conceptualized, implemented, and examined for effectiveness vis-à-vis hospital readmission reductions. These interventions include, but are not limited to, improved oral and written communication between providers and family members,^[9-11] post-discharge support teams,^[10] multidisciplinary provider teams,^[12] coordinated care,^[13-15] home-based care,^[16] emphasis on medication reconciliation and adherence,^[17,18] patient hotlines, follow-up appointments, patient education and engagement,^[19,20] tele-monitoring,^[21] and discharge planning,^[12,22,23] among others. The evidence centered on the efficacy of these interventions is quite mixed. For example, some researchers have generally found that discharge planning interventions are effective in reducing hospital readmissions,^[23,24] while others have found inconsistent or moderate effects of similar interventions on readmission rates.^[12,22] Findings from research on the effectiveness of transition of care interventions (TOCs) are also mixed. Generally, TOCs are sets of actions taken by clinical staff to ensure patient coordination and continuity of care as patients are shifted between various hospital units (e.g. an emergency department to an intensive care unit) and/or different locations (e.g. hospital to home).^[15] While some researchers have found that TOCs have been associated with significant decreases in hospital readmission rates,^[13,17] others have not found such an association.^[25] Moreover, studies that have examined the efficacy of medication reconciliation interventions have also provided conflicting findings.^[12,26,27]

To further add complexity, many of the study samples in the literature examining interventions targeted toward reducing hospital readmissions have been specific to certain sub-populations. For example, several studies have tested interventions on the elderly population only,^[28-31] while others have exclusively focused on joint replacement,^[10] heart failure,^[13,19-21,32] stroke,^[25] and Medicare^[33] patients. Thus, the breadth and strength of the evidence-base on interventions to address hospital readmission is difficult to ascertain because of heterogeneity in the patient populations, interventions, clinical settings, and implementation strategies that

have been examined and adopted. This heterogeneity also makes efforts to keep abreast of current findings on the part of hospital managers and clinicians especially arduous.

Therefore, the purpose of this study was to conduct a systematic review that will outline the state of the literature across interventions, populations, and various diagnoses. We were interested in any articles that examined the relationship between a targeted intervention and hospital readmissions on the following commonly occurring diagnoses: heart failure, acute myocardial infarction (AMI), COPD, bronchitis and asthma, pneumonia and other respiratory tract infections, sepsis, stroke, and TKA or THA. Our work supplements previous reviews of the readmission intervention literature that have narrowly focused on care delivered in patients' homes,^[16] nurse-assisted case management,^[14] medication reconciliation,^[26,27,34] self-management programs,^[19] and TOC interventions.^[15,25,35] In our study, we were broadly interested in determining what kinds of interventions are most promising for reducing hospital readmissions among patients with the aforementioned commonly occurring diagnoses. We were also interested in determining where major gaps exist in the literature. To identify these gaps, we set out to quantify the number of studies on specific interventions and their effectiveness on readmissions across various diagnoses. Overall, our study will be useful to hospital managers, clinicians, case managers, public health personnel, and researchers interested in reducing the occurrence of short-term hospital readmissions and improving care associated with index hospitalizations in the U.S.

2. METHODS

Following the PRISMA review checklist,^[36] we used a systematic review methodology to identify and extract information from articles that examined the efficacy of interventions aimed at reducing short-term hospital readmissions. We included articles published from January 2000 to August 2018. To be as comprehensive as possible, we enlisted the assistance of a professionally trained library science expert. We searched the MEDLINE and EMBASE databases for search terms such as "patient readmission", "readmit", "repeated hospitalization" and "re-hospitalization" to capture studies done on readmission. Moreover, we used terms such as "myocardial infarction", "heart failure", "asthma", "replacement", "chronic obstructive lung disease", "pneumonia", "stroke", "cerebrovascular disease", "cerebrovascular accident", "intracranial hemorrhage" and "respiratory tract infections" to capture articles that specifically examined readmissions among diagnoses commonly associated with short-term readmissions for which hospitals are being scrutinized. We only considered English-language, U.S.-based empirical

publications that appeared in peer-reviewed journals. Because we were exclusively focused on the evidence base for the impact of various interventions on readmissions, we ex-

cluded policy briefs, letters to the editor, and governmental reports outlining the general problem.

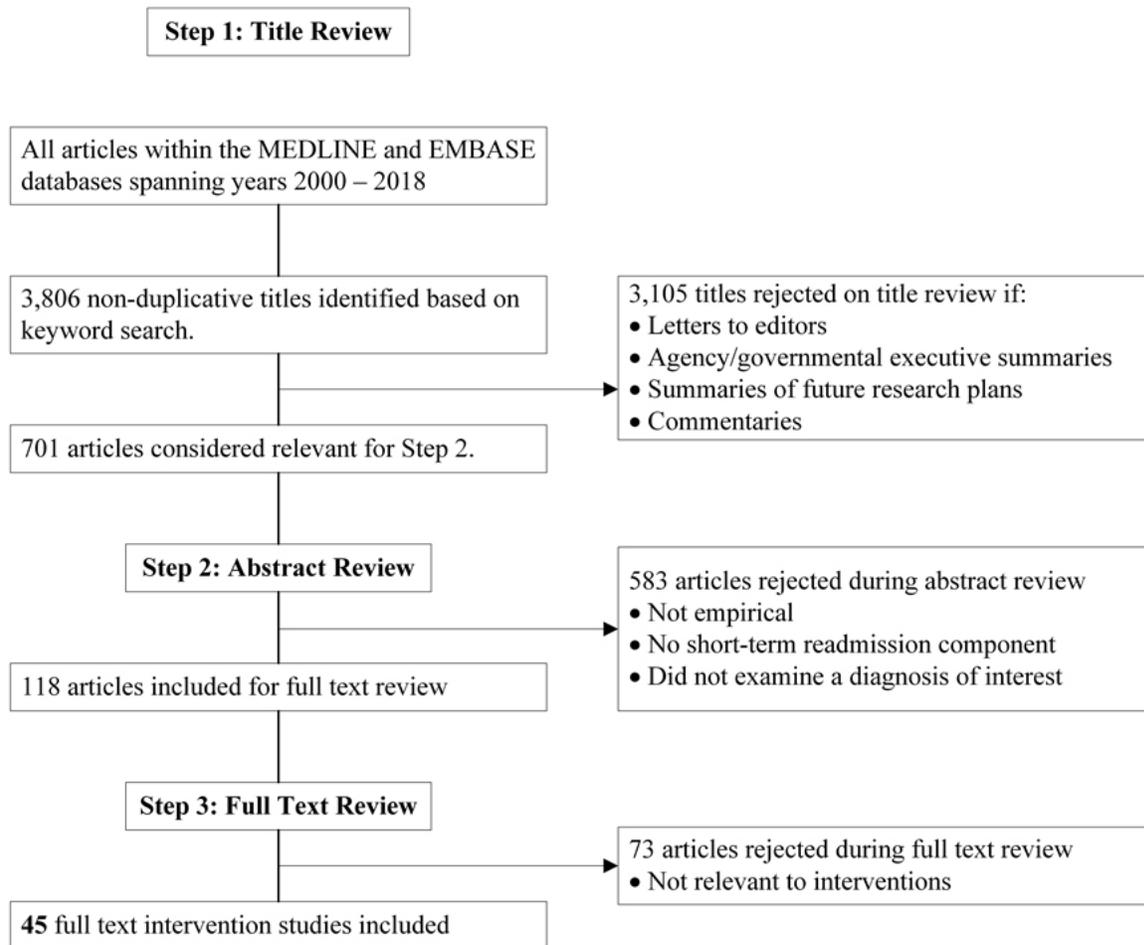


Figure 1. Identification of literature examining the effectiveness of interventions aimed at hospital readmission

Our keyword search identified 3,806 articles through our search of the aforementioned databases. We used a 3-step inclusion process outlined in Figure 1. In the first step, two independent reviewers (A.T.B. and A.O.F.) examined article titles and each flagged articles for elimination that did not indicate a focus on short-term readmission and one of the diagnoses of interest. The comprehensive nature of our search terms picked up articles that did not fit squarely in the scope of our study. For example, our initial search captured many articles that examined the association of specific operational or pharmaceutical interventions on short-term readmissions,^[37–39] and the use of various readmission metrics in predicting unplanned readmissions.^[40–42] We sought a high level of sensitivity in this first step in that we erred on the side of inclusion. Letters to editors, governmental summaries, and commentaries were excluded in this step. Consequently, if either reviewer chose to include an article

on the basis of the title, it was selected for abstract review in step 2. We included a total of 701 titles (18%) once this step was completed.

The second step involved screening the abstracts of the 701 articles identified in step 1. During this phase of our literature search, we focused on a high level of specificity by excluding articles that were not empirical studies and did not examine one of the diagnoses of interest. Disagreements or uncertainty about inclusion or exclusion was reconciled by group discussion among the authors. We included a total of 118 articles once this step was completed. Because of our interest in identifying procedural and behavioral interventions that are effective in reducing short-term readmissions, we conducted a third step in which we identified studies that explicitly examined readmission outcomes subsequent to the implementation of a non-clinical or medicinal intervention.

We included a total of 45 articles in this systematic review. These 45 studies represented 66 individual analyses because several papers presented two or more separate analyses that fit our inclusion criteria.

Next, we systematically classified all included studies by using a standard coding sheet specifically developed for this study. For each intervention study, we collected information on traits of the sample, such as the sample size, and whether race, gender, and age were considered in the study. We additionally collected information on whether patients with specific types of insurance coverage were included in the study (e.g. Medicare or Medicaid), and whether a study considered patients' educational attainment in their examination of the effectiveness of an intervention. In examining interventions used, we also distinguished between studies that examined one intervention independently and those that examined bundled interventions (for example studies that examined an intervention that included telephone follow-up, discharge planning, and collaboration among providers). We differentiated interventions based on 12 categories on the basis of existing literature,^[43,44] and coded them with the intervention name, description, clinic setting, study design. We additionally gathered information on whether each study found a beneficial association between the intervention(s) under study and short-term readmission (i.e. whether there was a reduction in readmission), a non-significant association, or an association that yielded mixed results. Studies were rated using a modified scheme from the Oxford Centre for Evidence-based Medicine to rate evidence quality from 1 (high) to 5 (low) quality.^[45]

3. RESULTS

We included a total of 45 articles in this review. These 45 studies represented 66 individual interventions because several papers presented two or more separate interventions that fit inclusion criteria. The number of articles examining the association of interventions on short-term hospital readmissions increased over time with one article published before 2000 and 35 published between 2011 and 2016. Sample sizes varied considerably among the studies with one study utilizing a sample of less than 50 participants and 14 studies examining the effects of interventions with more than 1,000 sample participants. The age group most frequently considered among the studies was the 65 or older age cohort. Eleven studies focused on individuals aged 18 to 64. Gender was also considered in most studies. 35 studies considered patients' gender in their models. Most studies, however, did not consider individual educational attainment or income levels of their samples in their analyses. Additionally, 28 of the 45 articles did not consider or provide information about

individual insurance status in their studies (see Table 1).

Table 1. Descriptive findings of selected intervention studies (N = 45 studies)

Variables	Number of articles	(%)
Year		
• < 2000	1	2%
• 2000-2005	3	7%
• 2006-2010	6	13%
• 2011-2016	35	78%
Sample Size		
• < 50	1	2%
• 51-100	3	7%
• 101-500	19	42%
• 501-1,000	8	18%
• 1,001-22,000	14	31%
Insurance Type		
• Medicare	16	36%
• Medicaid	7	16%
• Private	7	16%
• Not Included	28	62%
Race		
• Caucasian	25	56%
• Black	24	53%
• Hispanic	9	20%
• Other*	20	44%
• Not Included	14	31%
Age		
• < 2	2	4%
• 2-18 years	2	4%
• 18-64 years	11	24%
• ≥ 65 years	27	60%
• Not included	3	7%
Education		
• Included (Less than college)	3	7%
• Not Included	42	93%
Income		
• Included	0	0%
• Not Included	45	100%
Gender		
• Included	35	78%
• Not Included	10	22%
Study reported a statistically beneficial relationship between the intervention and short-term readmission		
• Yes	20	44%
• No	23	51%
• Partially**	2	4%

Note. * "Other" race includes Asian, Pacific Islanders, American Indian or Alaska Native; ** "Partially" under study result indicates the findings show mixed result according to patient diagnosis groups and intervention programs

A list and description of the interventions aimed toward reducing short-term hospital readmissions can be found in Kash et al.'s study.^[43,44] A breakdown of the number of studies examining various strategies and the number finding beneficial, null, or mixed effects can be found in Table 2. Of the 11 studies that examined educational strategies, in which patients and/or family members are educated on the diagnosis in question in an effort to enhance knowledge and

involvement in care, 4 found beneficial results of such an intervention, while 6 studies did not find beneficial reductions in short-term readmissions following an education-based intervention. Of the 9 studies that examined strategies centered around collaboration (i.e. interventions that involved activities conducted by a multidisciplinary team), 3 found beneficial associations between the intervention and readmission, while 6 reported null findings. The three studies that found a beneficial relationship between the collaborative interventions and readmission reductions had samples that were primarily made up of elderly, female, and Cau-

casian heart failure patients. These sample characteristics were quite different to the samples of the 6 studies reporting null findings. These studies' participants primarily consisted of children under 18 who had been diagnosed with asthma, COPD, bronchiolitis, or pneumonia. The findings indicate that the efficacy of interventions on short-term readmission reduction can be highly dependent on diagnosis and patient characteristics.

The detailed information for the studies finding beneficial outcomes in readmission reductions are listed in Table 3.

Table 2. Descriptive analysis of intervention studies (N = 45 articles, 66 interventions)

Type of Intervention	Description of Intervention	Count	Positive Results (%)	Negative or Not-significant Results (%)	Mixed Results (%)*
1 (Collaboration)	A variety of activities of a multidisciplinary team or group that includes diverse professions	9 (14%)	3 (33%)	6 (67%)	0
2 (Home visits)	Physical visits by healthcare provider(s) to patient's home; Regular home visits by profession(s)	1 (2%)	1 (100%)	0	0
3 (Telephone follow-up)	Use of telephone or videophone for provided-initiated communication initiated after discharge	5 (8%)	3 (60%)	2 (40%)	0
4 (Education)	Patient-directed education or coaching to diagnosis or treatment rationale in order to increase patient/family's knowledge and enhance their involvement in care	11 (17%)	4 (36%)	6 (55%)	1 (9%)
5 (Medication reconciliation)	Medication reconciliation or special education conducted by pharmacist and/or nurse, which is aimed at improving medication understanding or adherence before discharge	5 (8%)	3 (60%)	1 (20%)	1 (20%)
6 (Discharge planning)	Formalizing an approach to prepare for discharge; Establishing a transitional care plan before discharge	5 (8%)	2 (40%)	3 (60%)	0
7 (Follow-up appointment)	Scheduling a follow-up visit with patients during their hospital stay	1 (2%)	1 (100%)	0	0
8 (Tele-monitoring)	Use of remote technology designed for patients to transmit objective measures of health status with or without connected subjective assessment	5 (8%)	3 (60%)	2 (40%)	0
9 (Guideline implementation)	Adoption of and adherence to guidelines including rules or regulations about clinical treatment; Compliance with guidelines regarding staffing like work-hour restrictions	8 (12%)	3 (38%)	4 (50%)	1 (13%)
10 (Rehabilitation)	Patient-directed rehabilitation efforts that are not entirely diagnosis specific but aimed at improving functional status	2 (3%)	1 (50%)	1 (50%)	0
11 (Clinical, medical device)	Implementation of certain drug or surgery treatment; Use of an innovative medical device in a surgery or medical care to improve clinical outcomes	7 (11%)	3 (43%)	4 (57%)	0
12 (In-hospital management)	Hospital wards, staffed by doctors, nurses and other health professionals for diagnostic assessment, therapy, rehabilitation, and placement of patients to intensify post discharge care, identify effective community services and enhance primary care access	7 (11%)	2 (29%)	5 (71%)	0

Note. Mixed results signify studies that rendered different results, for example by hospital sites or by diagnoses. Description of intervention reprinted with permission from Kash et al.^[44]

Table 3. Characteristics of studies finding beneficial associations between interventions and short-term readmissions

Authors	Type	Intervention Description	Diagnosis	Outcome	Significance	Takeaway points	Quality of Evidence
Akosah et al., 2002	1, 12	Short-term, aggressive-intervention heart failure clinic (HFC)	Heart failure	Readmission, mortality rate	Compared to patients followed by their primary care physicians, there was a 77% relative risk reduction for 30-day hospital readmission, and a lower rate of readmissions at 90 days and 1 year in the intervention group. Additionally, combined hospital readmission and mortality rate at 90 days (10% vs. 30%, $p < .018$) and 1 year (21% vs. 43%, $p < .02$) was lower in patients referred to the HFC (intervention group).	HFC patients experienced fewer re-hospitalizations and improved event-free survival compared to patients followed up by their primary care physicians.	3
Amarasingham et al., 2013	8	Intensive set of evidence-based interventions, using electronic medical record (EMR)	Heart failure	Readmission for any cause and to any hospital within 30 days of discharge	The unadjusted readmission rate declined from 26.2% in the pre-intervention period to 21.2% in the post-intervention period ($p = .01$), a decline that persisted in adjusted analyses (adjusted OR [AOR] = 0.73; 95% CI 0.58 to 0.93, $p = .01$).	An EMR-enabled strategy that targeted scarce care transition resources to high-risk HF patients significantly reduced the risk-adjusted odds of readmission.	2
Anderegg et al., 2014	5, 6, 12	Innovative medication reconciliation and discharge education program in pharmacy services	Anticoagulation, CHF, COPD, AMI, Pneumonia	30-day readmission and emergency department (ED) visits	In the high-risk subgroup (defined as those receiving anticoagulation therapy or treatment for AMI, COPD, CHF, or pneumonia), there was a significant reduction in the 30-day rate of hospital readmissions, which declined from 17.8% to 12.3% ($p = .042$). Cost projections indicated that this reduction in readmissions could yield annual direct cost savings of more than \$780,000.	Implementation of a team-based pharmacy practice model yielded a significant decrease in the rate of 30-day readmissions for high-risk patients.	2
Baker et al., 2015	1	Inter-hospital collaborative approach	Heart failure	7-day post-discharge follow-up rates and 30-day readmission	During the intervention period, unadjusted readmissions decreased significantly (29.0% to 27.3%; $p < .001$).	See You in 7 Collaborative participation was associated with significantly lower 30-day readmissions	2
Benzo et al., 2016	4,5	Health coaching and action plan for the use of antibiotics and oral steroids	COPD	30-day and 90-day readmissions	The absolute risk reductions of COPD-related rehospitalization in the intervention arm compared with the control arm were 7.5% ($p = .01$) at 30-day postdischarge, and 11.0 ($p = .02$) at 90-day postdischarge.	Health coaching can be an effective intervention designed to reduce COPD readmissions	1
Dean et al., 2006	9	Pneumonia guideline implementation	Respiratory failure and sepsis from pneumonia	30-day all-cause mortality, length of hospital stay, and readmission rate	A 1-SD increase (10%) in guideline compliance was associated with a lower readmission rate after guideline implementation [odds ratio (95% CI) = 0.86 (0.78 to 0.96), $p = .006$].	Improved clinical outcomes were associated with pneumonia guideline utilization.	4
Jones et al., 2011	10	A pilot program for provision of Post Acute Care (PAC)	Neurological diagnosis (commonly stroke)	Post-discharge readmission and emergency department visits	The 30-day readmission rate for adult day program participants was significantly lower than that for non-participants; 6.1% vs. 22.2% ($p = .05$).	An expanded adult day program may represent a viable Transitional Care Model for selected patients and a feasible alternative to skilled nursing facility and home health care for PAC.	4
Lichtman et al., 2009	9	Joint Commission Primary Stroke Center certification program	Ischemic stroke	Mortality, 30-day mortality, and 30-day readmission	In-hospital mortality (OR, 0.93; 95% CI, 0.90 to 0.96), 30-day mortality (OR, 0.92; 95% CI, 0.87 to 0.96), 30-day readmission (hazard ratio, 0.97; 95% CI, 0.95 to 0.99) were lower in the future Joint Commission-certified hospitals.	Joint Commission Primary Stroke Center-certified hospitals had better outcomes than noncertified hospitals even before the program began.	3
Luder et al., 2015	1	Community pharmacy-based transition of care (TOC) program	CHF, COPD, and pneumonia	Hospital readmissions, resolved medication-related problems, and increased patient satisfaction	20% of patients in the usual care group were admitted to the hospital within 30 days compared to 6.9% of patients in the intervention group ($p = .019$).	Community pharmacies successfully collaborated with hospitals to develop a referral process for TOC interventions. Patients who received MTM services from the pharmacist experienced significantly fewer readmissions than patients who received usual care.	2
Maeng et al., 2014	8	Tele-monitoring	Heart failure	Hospital admission rates, readmission rates, and total cost of care	Significant reductions in probability of all-cause admission (odds ratio [OR] 0.77; $p < .01$), 30-day and 90-day readmission (OR 0.56, 0.62; $p < .05$), and cost of care (11.3%; $p < .05$).	These findings imply that tele-monitoring can be an effective add-on tool for managing elderly patients with heart failure.	3
Ota et al., 2013	3	Direct Telephonic Communication in a Heart Failure Transitional Care Program (HFTCP).	Heart failure	30-day readmission	Structured post-discharge follow up protocols have been shown to help prevent and reduce HF hospitalizations, especially 30-day readmissions.	This program reduces unnecessary hospitalizations and reduces costs while giving patients the security of having immediate access to their provider.	4

(Table continued on page 22)

Table 3 (continued.)

Authors	Type	Intervention Description	Diagnosis	Outcome	Significance	Takeaway points	Quality of Evidence
Robbins et al., 2014	11	Total Hip Arthroplasty (THA)-Accelerated Rehabilitation (AR) protocol	Total hip arthroplasty	Early mobilization, length of stay, complication, and hospital readmissions	Accelerated rehabilitation (AR) protocol patients were more likely to be discharged home and to have fewer postoperative complications and rehospitalizations. Among 16 reported readmission for the 590 patients included in this retrospective review, only one was an AR patient.	A THA-AR protocol can decrease LOS, influence discharge disposition, and decrease the likelihood of postoperative complications and rehospitalizations.	4
Roglieri et al., 1997	8, 3, 4	A comprehensive congestive heart failure (CHF) disease management program	CHF	Hospital admission and readmission rates, length of stay, total hospital days, and emergency room utilization	Overall, there were significantly reduced admission and readmission rates for patients with the pure CHF diagnosis; 30-day and 90-day readmission rates declined 75% ($p = .02$) and 74% ($p = .004$), respectively. Reductions were also seen in total hospital days and emergency room utilization.	A comprehensive disease management program can reduce healthcare utilization not only among CHF patients in the program but also among the entire managed care plan population.	3
Rothberg et al., 2010	5	Antibiotic therapy	COPD	Treatment failure, inpatient mortality, or readmission for acute exacerbations of COPD within 30 days of discharge	Of 84,621 patients, 79% received at least 2 consecutive days of antibiotic treatment. Treated patients were less likely than non-treated patients to receive mechanical ventilation after the second hospital day, and had lower rates of readmission for acute exacerbations of COPD (7.91%; 95% CI, 7.89%-7.94% vs. 8.79%; 95% CI, 8.74%-8.83%)	Early antibiotic administration was associated with improved outcomes among patients hospitalized for acute exacerbations of COPD regardless of the risk of treatment failure.	3
Ryan et al., 2014	9	Quality improvement (QI) program	Heart failure	The percentage of patients who had preventable readmissions in each year	The 30-day readmission rate decreased 28% ($p = .04$) following the initiative of Quality Improvement program	This study identified 20% to 30% of 2008 readmissions preventable based on chart review by multiple providers having different clinical backgrounds. This range contains the actual 28% readmission reduction rate that occurred following the UCONN HF QI program (intervention). Preventable readmissions were less common after the QI program was in place.	3
Ryan et al., 2013	7	Hospital quality improvement initiative	Heart failure	30-day readmission rate	Thirty-day all-cause readmissions decreased from 27.5% to 19.1% after our quality improvement initiative ($p = .024$)	Our hospital's 30-day readmission rate for patients with heart failure decreased in parallel with an increase in 7-day follow-up visits.	3
Sales et al., 2014	3, 6, 4	Pharmacologic education by a trained volunteer; receiving dietary, follow-up calls	CHF	30-day readmission	The intervention arm (Arm A) patients, who received dietary and pharmacologic education by a trained volunteer, had decreased 30-day readmissions (7% vs. 19%; $p < .05$) with a relative risk reduction (RRR) of 63% and an absolute risk reduction (ARR) of 12%.	Utilizing trained volunteer staff to improve patient education and engagement might be an efficient and low-cost intervention to reduce CHF readmissions.	1
Scotti et al., 2015	11	Percutaneous ventricular assist devices (pVADs) and extracorporeal membrane oxygenation (ECMO)	Cardiogenic Shock (CS)	30- and 90-day readmissions, associated length of stay (LOS), and costs	At 90 days after initial hospitalization, the readmission rates in the pVAD and ECMO cohorts were 38.7% (200/517) and 53.0% (70/132), respectively. Overall, pVAD was associated with a 27.1% reduction in readmission ($p = .004$).	Increased adoption of pVAD, as a technology to support patients in cardiogenic shock, may help hospitals deliver greater value to both government and commercial payers.	3
Snider et al., 2015	11	Oral nutritional supplementation (ONS)	COPD	Readmission, length of stay (LOS), and cost	ONS use was associated with longer LOS (8.7 days vs. 6.9 days, $p < .0001$), higher hospitalization cost (\$14,223 vs. \$9,340, $p < .0001$), and lower readmission rates (24.8% vs. 26.6%, $p = .0116$).	ONS may be associated with reduced LOS, hospitalization cost, and readmission risk in hospitalized Medicare patients with COPD.	4
Stauffer et al., 2011	2, 4	Nurse-led transitional care programs	Heart failure	30-day all-cause readmission rate, length of stay, and 60-day (from admission) direct cost	The intervention significantly reduced adjusted 30-day readmission rates by 48% during the post-intervention period. The intervention, however, had little effect on length of stay or total 60-day direct costs.	Preliminary results suggest that transitional care programs reduce 30-day readmission rates for patients with heart failure. This underscores the potential of the intervention to be effective in a real-world setting, but payment reform may be required for the intervention to be financially sustainable by hospitals.	2

Note. The type of interventions are defined in Table 2

Given the heterogeneous ways in which interventions were implemented among the studies, we determined whether interventions were implemented as a single construct or op-

erationalized in a bundled fashion. We found that 16 of the 45 studies examined bundled interventions (i.e. interventions that incorporated more than one strategy in tandem), while

29 studied the implementation of a single intervention. Educational strategies were more frequently bundled with telephone follow-up, medication reconciliation, and discharge planning, while collaboration was more frequently bundled with in-hospital management and guideline implementation, indicating more of a focus on internal management. Generally, a higher proportion of the singularly-implemented interventions found beneficial associations on readmission (16 of 29 studies [55.2%]) than the bundled interventions (6 of 16 studies [37.5%]).

When looking at intervention strategies and effectiveness by diagnosis type, we found that 50.7% of included studies examined readmission among heart failure patients (see Table

4). Of the 40 examined interventions among heart failure patients, 21 (52.5%) of them found that interventions were beneficial in reducing readmission. We note that tele-monitoring was the most consistent intervention with beneficial results in readmission reductions among heart failure patients. Despite the common and pervasive occurrence of sepsis among hospitalized individuals, we found that no studies had examined interventions and short-term readmission among sepsis patients. The evidence-base for intervention efficacy among THA/TKA (n = 2), and stroke patients (n = 2) is also quite limited, suggesting that future research should seek to fill these gaps in knowledge in order to improve outcomes for these patients.

Table 4. Number of studies by diagnoses and interventions

	Heart Failure	AMI	COPD	Bronchiti/Asthma	Pneumonia and Other Respiratory Tract Infections	Sepsis	Stroke	Hip or Knee Joint Replacement
Collaboration	5 (3)	0	2 (1)	2 (0)	2 (1)	0	0	0
Home visits	1 (1)	0	0	0	0	0	0	0
Telephone follow-up	4 (3)	0	1 (0)	0	0	0	0	0
Education	8 (3)	0	3 (1)	0	0	0	0	0
Medication reconciliation	2 (1)	1 (1)	3 (3)	0	2 (1)	0	0	0
Discharge planning	5 (2)	1 (1)	1 (1)	0	1 (1)	0	0	0
Follow-up appointment	1 (1)	0	0	0	0	0	0	0
Tele-monitoring	5 (3)	1 (0)	0	0	1 (0)	0	0	0
Guideline implementation	3 (1)	0	1 (0)	1 (0)	1 (1)	0	1 (1)	1 (1)
Rehabilitation	1 (0)	0	0	0	0	0	1 (1)	0
Clinical, medical device	2 (1)	0	3 (1)	1 (0)	0	0	0	1 (1)
In-hospital management unit	3 (2)	2 (1)	1 (1)	2 (0)	2 (1)	0	0	0
Total number of interventions by diagnosis	40 (21)	5 (3)	15 (8)	6 (0)	9 (5)	0	2 (2)	2 (2)

Note. The numbers in parenthesis indicate the number of interventions with positive impacts on 30-day readmissions. The total number of interventions by diagnosis (79) is greater than the number of interventions (66) in Table 1 because some articles include analyses of more than one diagnosis

4. DISCUSSION

In this systematic review paper we first report that the number of studies focused in readmission reduction interventions has increased dramatically since 2000, adding to our knowledge of effective interventions and our ability to follow more evidence-based strategies to reduce hospital readmissions. Successful interventions targeted towards reducing readmission rates are presented and discussed next. One important observation is that from an organizational point of view, it is difficult to isolate the effect of single interventions as these

interventions are often executed in bundles. For example, we found that educational strategies were more frequently bundled with telephone follow-up, medication reconciliation, and discharge planning. Due to the bundled nature of interventions, it is very difficult to design a study to evaluate the effect of one single intervention in a health care setting today.

Another key consideration in designing interventions to reduce readmission rates is disease category and patient population segments. Both patient education and collaboration

type interventions show mixed results and seem to be highly dependent on disease and setting. For example, collaboration interventions demonstrate significant positive results for patients with heart disease, which is also the most studied disease type. These mixed results lead us to conclude that for readmission reduction interventions to be successful, they need to be targeted towards specific patient segments and disease categories. Furthermore, the success of each of these initiatives may be primarily patient-driven. Shared accountability for clinical outcomes between patients and healthcare teams represents an evolving and increasingly important concept in healthcare practice today. This paradigm is commonly described in the context of values-based medicine, a framework for clinical practice, which requires true partnerships between patients, providers and health systems to optimize healthcare outcomes.

Finally, future research on readmission reduction interventions should consider including additional context variables, such as socioeconomic factors, in readmission reduction studies and prediction models. We found that most studies did not consider income, insurance status, or provider characteristics in their studies. Overall, our findings indicate a major opportunity for researchers to pursue studies that employ tools that provide additional context and specificity so as to better inform the execution of interventional strategies in healthcare organizations.

Our study has noteworthy limitations. First, it is possible that our search protocol neglected to include some studies that may have been worthy of inclusion. To minimize this

possibility, we consulted with a systematic review librarian, experimented with various search terms, and attuned our approach to err on the side of inclusion during the first phase of our search. Second, our sample size of 45 articles limited our ability to conduct complex analyses. This is especially true given that so many interventions are understudied as they relate to specific diagnoses. As health care delivery organizations and professionals continue to seek ways in which to improve quality of care, and by extension, population health, future work should further seek to identify the significant predictors of successful interventions as they relate to stemming unplanned hospitalizations.

5. CONCLUSIONS

This study reveals that readmission reduction interventions are executed in bundles and have mixed results based on patient population and diagnosis. Future research should consider additional context and specificity so as to better inform the successful readmission reduction strategies in healthcare organizations.

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CONFLICTS OF INTEREST DISCLOSURE

The authors declare they have no conflicts of interest.

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