Impact of a Pharmacy-Based Transitional Care Program on Hospital Readmissions

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ABSTRACT

OBJECTIVES: Avoidable readmissions of patients discharged from hospitals are a major concern. This study evaluates the impact of pharmacist-provided postdischarge services on hospital readmissions for members of a US managed Medicaid health plan.

STUDY DESIGN: Prospective cohort study.

METHODS: Synergy Pharmacy Solutions (SPS) initiated a transition of care (TOC) service for high-risk members of the Kern Health Systems (KHS) managed Medicaid plan. Over 1100 patients were referred to SPS between April 2013 and March 2015. KHS classified hospitalized members as high risk for readmission based on prior healthcare utilization, a health risk assessment questionnaire, and the use of the Johns Hopkins predictive modeler. This study compares SPS TOC recipients with a matched sample of KHS members discharged from nonintervention hospitals. Thirty-day and 180-day readmissions and time-to-readmission were defined as outcomes. Logistic regression and Cox model were estimated, controlling for demographics, diagnostic and drug profiles, and prior hospital utilization.

RESULTS: KHS identified 1763 high-risk discharges from nonintervention hospitals, of which 1005 and 669 were matched to 830 and 558 selected SPS patients in 30-day and 180-day populations, respectively. The SPS postdischarge intervention reduced the risk of readmission within 30 days by 28% (odds ratio [OR], 0.720; 95% confidence interval [CI], 0.526-0.985) and within 180 days by 31.9% (OR, 0.681; 95% CI, 0.507-0.914). The estimated effect of the SPS intervention from the Cox model was a reduction in risk of 25% (hazard ratio, 0.749; 95% CI, 0.566-0.992).

CONCLUSIONS: A community pharmacy-based postdischarge TOC program can significantly reduce readmission rates at 30 and 180 days compared with usual discharge care.

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Patients with complex medical histories and medication regimens who are admitted to the hospital are at risk for readmission due to a number of factors, including lapses in the continuity of care. The average 30-day readmission rate in the United States is about 16%.[1] These high readmission rates have imposed a significant clinical and economic burden on the US healthcare system. As a result, the Hospital Readmissions Reduction Program, enacted in October 2012, directed that CMS reduce payments to hospitals with excess 30-day readmission rates for conditions like acute myocardial infarction (AMI), heart failure, pneumonia, chronic obstructive pulmonary disease (COPD), total hip arthroplasty, and total knee arthroplasty.[2] Thus, it is critical to identify the reasons for readmissions and to implement programs to decrease the risk of readmissions.

Suboptimal medication therapy during the transition of care (TOC) period following hospital discharge is a major contributory factor to hospital readmissions and increased healthcare utilization.[3] Forster et al estimated that 11% of patients experienced an adverse drug event after discharge from inpatient services, and 27% of readmissions were considered to be preventable if the patient had received appropriate postdischarge medication monitoring.[4] Additionally, several services have been shown to impact hospital readmissions, including patient education, medication adherence counseling, and medication reconciliation.[5-11] Pharmacist involvement in discharge counseling, medication reconciliation, and telephone follow-up has resulted in a lower incidence of preventable adverse drug events.[7-10] Consequently, it is reasonable to expect that pharmacist-led TOC services may decrease readmission rates.

Synergy Pharmacy Solutions (SPS) in Bakersfield, California, initiated an ambulatory care pharmacy-based TOC service in 2013 for recently discharged members of the Kern Health Systems (KHS) managed Medicaid health plan who were classified as high risk based on their healthcare utilization, medical history, and social history and the use of the Johns Hopkins predictive modeler. High-risk members admitted to a single local hospital were referred

to SPS for postdischarge services. Over 1100 members were referred to SPS between April 2013 and March 2015.

This study evaluated the effect of the ambulatory care pharmacy-based TOC services provided by SPS on 30-day and 180-day readmissions compared with a control group of matched KHS members discharged from neighboring hospitals.

TAKEAWAY POINTS

An ambulatory care pharmacy-based transition of care program reduced 30-day and 180-day readmission rates by 28% and 31.9%, respectively, compared with usual discharge care.

- The pharmacist interventions focused on patient education, resolving medication-related problems, and facilitating access to postdischarge appointments and medications.
- Previous studies evaluating pharmacist-provided care transitions have focused on specific disease states, had shorter follow-up periods, and/or included only academic or integrated health systems. The standalone clinic evaluated herein may be more generalizable to a variety of different practice settings.
- Future research may identify specific risk factors and interventions that affect readmissions.

METHODS

Ambulatory Care Pharmacy-Based TOC Program

The risk of readmission for individuals enrolled in KHS's managed Medicaid plan was evaluated based on their history of hospitalizations, prescription medication utilization, and social history. Adult patients discharged from a local hospital who were at high risk for readmission were automatically referred to the SPS TOC program. Those who met the following criteria were then excluded by the SPS team: discharged to a skilled nursing facility, rehabilitation facility, or hospice; died in hospital; left hospital against medical advice; or hospitalized for an elective procedure, obstetrical complications, substance abuse, a urinary tract infection, or a suicide attempt.

Intervention

Once the qualified patient agreed to participate in the SPS TOC program, medications were reconciled and any discrepancies between the patient's self-reported medication use and the hospital discharge orders were noted. Over the 30 days following discharge, the pharmacists worked with the outpatient providers to resolve any medication-related problems, such as inappropriate therapy, therapeutic duplications, and potential drug interactions. In addition, the pharmacists counseled patients to improve medication adherence. The pharmacy staff reinforced the discharge care plan, including postdischarge appointments, facilitating authorizations for specialist care, arranging transportation for appointments, and working with each patient's dispensing pharmacy to resolve insurance-related issues. Patients requiring additional assistance were invited for a face-to-face visit, which included more intensive counseling and assistance with organizing medications.

Medication management services were documented directly into the existing electronic health record (EHR) system of the ambulatory care pharmacy, which included customized reporting capabilities. Daily reports were generated by the pharmacy team, and follow-up tasks were assigned accordingly. The clinical pharmacy team acted as a liaison to bridge the communication gaps between the patients, their prescribers, and their dispensing pharmacy, thereby facilitating improvements in the continuity of care between the inpatient and outpatient settings.

Data Collection

The primary source of data for this study was the KHS paid claims database, which covered all enrolled beneficiaries' inpatient records, outpatient services, emergency department visits, and prescription claims for services rendered within the United States. *International Classification of Diseases, Ninth Revision, Clinical Modification* codes were used to identify diagnoses. Medications were identified using specific therapeutic class codes. The data related to TOC services were collected from the EHR system at SPS.

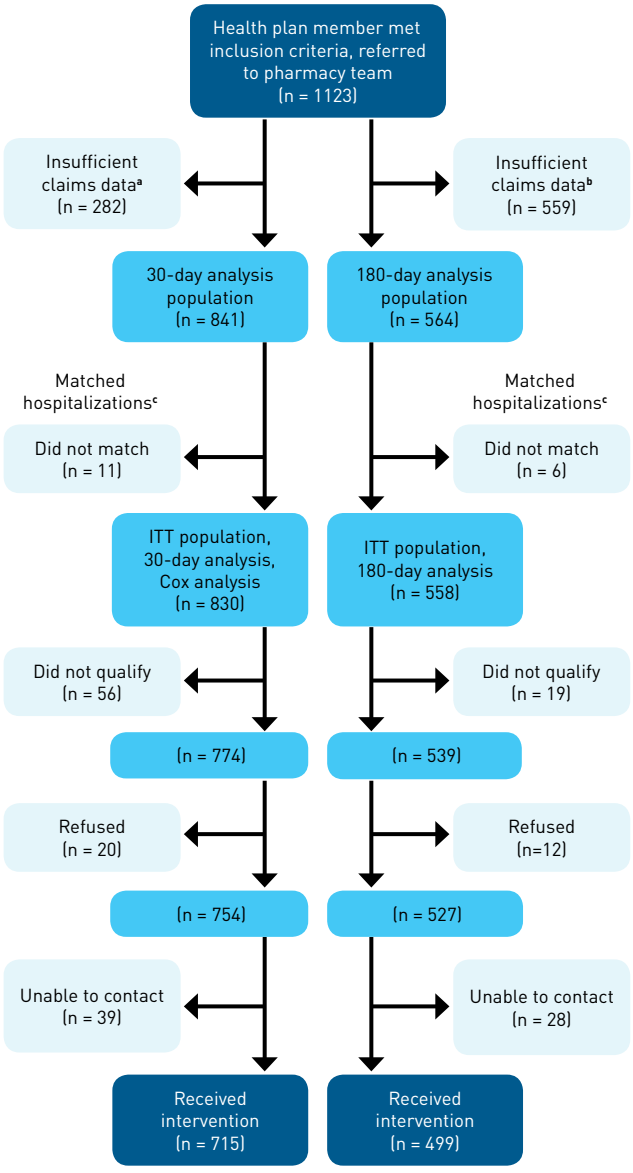
Study Population

The intervention and control patient populations were selected from the pool of adult Medicaid managed care members of KHS's health plan who were discharged from either the study hospital or the control hospital (other neighboring hospitals contracted with KHS in Kern County, California) and met the following inclusion criteria at the time of discharge: active members of KHS with an inpatient stay at participating hospitals and at least 1 of the following: 1) high risk, as determined by KHS's algorithm, including prior healthcare utilization and social history; 2) discharged with prescription claims for 5 or more medications; 3) admitted to any local hospital within the last 45 days.

For the intervention patients referred to SPS, an index date was defined as the discharge date of their hospitalization immediately preceding referral. All referred patients were screened for 6 months of continuous health plan enrollment prior to the index hospitalization and 30 days of postdischarge data. A second screen requiring 180 days of postdischarge data was applied for hospital admissions used in the analysis of readmission at 6 months.

The control group was identified retrospectively by applying the KHS risk-screening algorithm to its members discharged from neighboring hospitals between October 2012 and March 2015. In order to identify an index hospitalization for each control group patient, all hospitalizations for each patient were converted into episodes of hospital care and matched to the index episode in an intervention group member based on the number of prior hospitalizations and length of stay (LOS) ($\pm$ 1 day). In order to maximize the power of the analysis, we included all the patients from the control

FIGURE. Study Population Selection, Intervention Group



ITT indicates intent-to-treat

[a]180 days of claims data prior to first hospitalization and 30 days of claims data after first hospitalization.
[b]180 days of claims data prior to first hospitalization and 180 days of claims data after first hospitalization.
[c]Matching by ± 1 day of length of stay and prior hospitalization counts.

group who were matched to at least 1 patient in the intervention group. Thus, intervention patients could have more than 1 matched control hospitalization in the final study population.

A total of 1123 patients were referred to SPS, of which 830 met the enrollment criteria for the 30-day analysis and were matched to 1005 patients receiving usual care. A total of 558 SPS patients met the enrollment criteria for the 180-day analysis and were matched to 669 usual care patients (**Figure**). In the intervention group, all patients referred to SPS were included in this intent-to-treat (ITT) analysis, including those who did not qualify for services, who could not be contacted, and who declined services.

Outcome Measures

The primary outcome measures were all-cause 30-day and 180-day hospital readmissions, which were defined as inpatient stays within 30 or 180 days after the index hospitalization discharge date. The 180-day window was analyzed in order to evaluate the persistence of the intervention beyond 30 days. Time to readmission was also calculated and used as a secondary outcome measure. As a sensitivity analysis, the total count of hospital readmissions within 30 days and 180 days after the index date were compared between the intervention and control groups.

Statistical Analysis

Descriptive statistics were applied to test for differences in demographics and clinical characteristics between the intervention and control groups. A χ^2 test was used to test for baseline differences between intervention and control patients in the distribution of gender, race, age, and indicator of prior hospitalizations. Student's *t* test was utilized to compare the mean index hospitalization LOS and number of medications.

Logistic regression was used to estimate the impact of the TOC intervention on the likelihood of a 30-day or 180-day readmission. These models controlled for age, gender, race, prior hospitalizations (yes/no), LOS of the index hospitalization, inpatient diagnoses prior to and including the index hospitalization, and the mix of medication classes used by the patient over the 6 months prior to admission. Time to readmission was analyzed using a Cox proportional hazards model, controlling for the same covariates used in the logistic analyses. The study population for the Cox analysis was the same population used in the 30-day readmission analysis. For the sensitivity analysis, ordinary least squares (OLS) regression and Poisson regression models were used to estimate the effects of the TOC intervention on the count of hospitalizations within 30 days and 180 days after the index hospitalization controlling for demographic information, prior healthcare utilization, and comorbidities. Data analyses were performed using SAS version 9.4 (SAS Institute Inc, Cary, North Carolina) and STATA version 12 (StataCorp, College Station, Texas).

RESULTS

A total of 1123 patients were referred to the SPS TOC program during the study period, of whom 841 were continuously enrolled in the KHS Medicaid plan 6 months prior to and 30 days after the index hospitalization. After matching, 830 intervention patients and 1005

TABLE 1. Descriptive Statistics of ITT Population

	30-Day Population			180-Day Population		
	Intervention (n = 830)	Control (n = 1005)	*P*	Intervention (n = 558)	Control (n = 669)	*P*
Male (n and %)	269 (32.41%)	335 (33.33%)	.6751	179 (32.08%)	216 (32.29%)	.9381
Race (n and %)						
White	325 (39.16%)	354 (35.22%)	.0309	222 (39.78%)	241 (36.02%)	.3014
Hispanic	292 (35.18%)	414 (41.19%)		194 (34.77%)	259 (38.71%)	
Black	110 (13.25%)	107 (10.65%)		77 (13.80%)	81 (12.11%)	
Other	103 (12.41%)	130 (12.94%)		65 (11.65%)	88 (13.15%)	
Age groups, years (n and %)						
≤24	66 (7.95%)	65 (6.47%)	.0642	44 (7.89%)	52 (7.77%)	.4255
25-34	104 (12.53%)	139 (13.83%)		76 (13.62%)	103 (15.40%)	
35-44	117 (14.10%)	167 (16.62%)		86 (15.41%)	110 (16.44%)	
45-54	217 (26.14%)	297 (29.55%)		148 (26.52%)	198 (29.60%)	
55-64	275 (33.13%)	291 (28.96%)		175 (31.36%)	176 (26.31%)	
≥65	51 (6.14%)	46 (4.58%)		29 (5.20%)	30 (4.48%)	
Prior hospitalization (n and %)	269 (32.4%)	158 (15.72%)	<.0001	195 (34.95%)	73 (10.91%)	<.0001
Length of stay, days (mean and SD)	4.50 (3.8976)	3.80 (3.5485)	<.0001	4.45 (3.91)	3.56 (3.31)	<.0001
Number of medications, (mean and SD)	6.97 (3.2136)	6.78 (2.7855)	.1752	6.95 (3.11)	6.85 (2.81)	.547

ITT indicates intent-to-treat; SD, standard deviation

control observations were included in the logistic regression model for 30-day readmission. For the analysis of 180-day readmission, 564 referred patients were continuously enrolled in the KHS plan 6 months prior to and 30 days after the index hospitalization, of which 558 from the intervention group and 669 from the control group were matched.

Table 1 compares the baseline characteristics of the intervention and control groups. In the 30-day readmission population, the age, gender, and number of medications from the intervention and control groups were not statistically different, whereas the intervention group tended to have a higher proportion of prior inpatient admissions and longer index hospitalization LOS. In the 180-day matched population, the age, race, and gender of the 2 groups were similar. As in the 30-day population, the intervention group had a higher proportion of patients with prior inpatient stays and longer LOS. In order to control for the differences between groups, these demographics and clinical characteristics were used as independent variables in both the logistic and Cox models.

After controlling for confounders, the multivariate logistic regression analysis on 30-day readmissions showed that the SPS TOC intervention was associated with a statistically significant 28% reduction in 30-day readmissions (odds ratio [OR], 0.720; 95% confidence interval [CI], 0.526-0.985) (Table 2). Other factors associated with an increased risk of 30-day readmissions were prior inpatient stays (OR, 1.930; 95% CI, 1.255-2.969) and longer LOS (OR, 1.054; 95% CI, 1.018-1.091). Patients who were hospitalized for AMI, COPD, digestive diseases, infectious and parasitic diseases, and neoplasms had a higher likelihood of 30-day readmissions. In addition, patients with prescription claims for antiepileptic drugs, dialysis solutions, and dietary supplements (including intravenous nutrition) also had higher 30-day readmission rates.

The 180-day analysis indicated that the TOC intervention reduced readmissions at 6 months by 31.9% (OR, 0.681; 95% CI, 0.507-0.914) (Table 3). Patients with a prior hospitalization, COPD, and infectious and parasitic diseases were more likely to be readmitted within 180 days. Patients hospitalized for blood disorders and diabetes were more likely to be readmitted within 180 days, but not within 30 days. Use of dialysis solutions and dietary supplements, including intravenous nutrition, was associated with higher risk for 180-day readmissions, consistent with the 30-day outcomes.

The sensitivity analyses demonstrated that the SPS TOC service was associated with a reduction in the number of hospitalizations. The TOC program reduced the number of readmissions by 6 per 100 patients within 30 days and 19 per 100 patients within 180 days compared with patients receiving usual care (**eAppendix Table A** [eAppendices available at **www.ajmc.com**]).

Time to readmission was analyzed by the Cox proportional hazards model on the 30-day ITT population. After adjusting for all demographics and clinical characteristics, the model illustrated that patients receiving TOC services had a 25% lower hazard of readmission compared with patients receiving usual care (hazard ratio, 0.749; 95% CI, 0.566-0.992) (Table 4).

TABLE 2. Logistic Regression Analysis for Effect of TOC Intervention on 30-Day Readmissions, ITT Population[a]

Parameter	OR	95% CI	*P*
Intervention	0.720	0.526-0.985	.04
Gender			
Female	0.857	0.607-1.211	.3822
Male	ref	–	–
Race			
Black	1.191	0.739-1.921	.4732
Hispanic	0.789	0.547-1.139	.2056
Other	0.823	0.499-1.356	.4441
White	ref	–	–
Age groups, years			
≤24	ref	–	–
25-34	0.858	0.424-1.736	.6704
35-44	0.766	0.369-1.589	.4738
45-54	0.812	0.400-1.651	.5658
55-64	0.660	0.318-1.370	.2649
≥65	0.950	0.378-2.384	.9126
Length of stay, days	1.054	1.018-1.091	.0028
Indicator of prior hospitalization	1.930	1.255-2.969	.0027

CI indicates confidence interval; ITT, intent-to-treat; ref, reference group; OR, odds ratio; TOC, transition of care.
[a]Estimated impact of patient's medical conditions and medication history on 30-day readmission are listed in **eAppendix Table B**.

TABLE 3. Logistic Regression Analysis for Effect of TOC Intervention on 180-Day Readmissions, ITT Population[a]

Parameter	OR	95% CI	*P*
Intervention	0.681	0.507-0.914	.0106
Gender			
Female	0.981	0.715-1.344	.903
Male	ref	–	–
Race			
Black	1.014	0.650-1.582	.9505
Hispanic	0.873	0.629-1.211	.4152
Other	0.867	0.552-1.362	.5367
White	ref	–	–
Age groups, years			
≤24	ref	–	–
25-34	0.718	0.387-1.333	.2942
35-44	0.775	0.402-1.492	.4452
45-54	0.678	0.354-1.298	.2406
55-64	0.673	0.347-1.304	.2408
≥65	0.663	0.277-1.585	.3553
Length of stay, days	1.036	0.999-1.074	.0538
Indicator of prior hospitalization	3.728	2.434-5.709	<.0001

CI indicates confidence interval; ITT, intent-to-treat; ref, reference group; OR, odds ratio; TOC, transition of care.
[a]Estimated impact of patient's medical conditions and medication history on 180-day readmission are listed in **eAppendix Table C.**

DISCUSSION

This study estimated the impact of a community pharmacist-based TOC initiative on 30-day and 180-day readmission rates in a managed Medicaid population. Both the logistic regression and Cox proportional hazard models found that the TOC services at SPS were associated with significantly lower all-cause readmissions at 30 days and 180 days compared with usual discharge care. Accordingly, this study adds to the body of literature on the effects of TOC and the role of the pharmacist in TOC. Whereas previous studies have largely focused on TOC services within academic centers or closed systems, such as the Veterans' Health Administration, this study evaluates the impact of a stand-alone ambulatory care pharmacy-based TOC service. In addition, prior research on the impact of the pharmacist has focused on medication reconciliation prior to discharge. The SPS TOC program has demonstrated that medication-related problems often persist after discharge, which requires further interventions by pharmacists for the 30-day period after discharge. More details on these interventions will be described in future publications.

This study also adds to the body of literature on the impact of pharmacist-based TOC services. Many TOC interventions have shown the benefits of close postdischarge care coordination on readmission rates and healthcare utilization.[8,12-24] However, these studies either focused only on specific disease conditions or only evaluated the effects over a short period of time. O'Dell et al reported that clinical pharmacist services for cardiac patients with unstable angina were associated with lower readmission rates compared with usual care. However, the results were not significant in the larger pool of all cardiac patients.[23] Koehler et al designed a randomized clinical trial and showed that pharmacist-led interventions reduced 30-day readmissions but did not affect 60-day readmissions.[24] Kirkman et al also found that telephonic follow-up by pharmacists reduced 30-day readmissions; their regression analysis demonstrated that the 30-day readmission OR for patients who received usual care was 1.53.[15] When the reference category was reversed, the OR was comparable to our result of 0.72. To our knowledge, our 180-day analysis exceeds the follow-up period of existing studies.

All patients referred to the TOC services (the ITT population)—including those who did not qualify for services (6.7%), patients who could not be contacted (4.7%), and patients who declined services (2.4%)—were analyzed in this study. Thus, the results estimate the effects of TOC services on the entire referred population. The corresponding percentages in the 180-day population

TABLE 4. Cox Proportional Hazards Analysis on Time to Readmission[a]

Parameter	HR	95% CI	*P*
Intervention	0.749	0.566-0.992	.0435
Gender			
Female	0.873	0.639-1.191	.3914
Male	ref	–	–
Race			
Black	1.162	0.759-1.778	.4896
Hispanic	0.808	0.581-1.124	.2056
Other	0.873	0.555-1.373	.5573
White	ref	–	–
Age groups, years			
≤24	ref	–	–
25-34	0.842	0.447-1.585	.5941
35-44	0.744	0.387-1.430	.3755
45-54	0.795	0.424-1.493	.4762
55-64	0.671	0.350-1.283	.2275
≥65	0.922	0.412-2.065	.844
Length of stay, days	1.047	1.017-1.078	.0018
Indicator of prior hospitalization	1.8	1.227-2.639	.0026

CI indicates confidence interval; HR, hazard ratio; ref, reference group
[a]Estimated impact of patient's medical conditions and medication history on time-to-readmission are listed in **eAppendix Table D**.

were 3.4%, 2.2% and 5%, respectively. There were many possible reasons for patients refusing services or being unreachable by phone, including the "cold call" nature of the phone call from SPS, the perception that the TOC services were unnecessary, disconnected phone numbers, homelessness, or refusal to discuss their healthcare with a professional other than their own physician. Despite the inclusion of all of these patients in the analysis, the results demonstrated a significant reduction in readmissions associated with the intervention—an effect that may have been even larger had we excluded them from the analysis.

In addition to evaluating the impact of the SPS TOC program on readmission rates, this study explored the potential factors associated with higher readmission rates. In both the 30-day and 180-day analyses, prior hospitalizations within 6 months, COPD and infectious and parasitic diseases were significantly associated with increased risk of readmission. Similarly, using medications for electrolyte imbalance and dietary supplementation was shown to be related to higher readmission rates. It is possible that use of these prescriptions may be indicators for chronic illnesses, such as renal failure and/or gastrointestinal disorders. Although the current results described many factors that could potentially affect readmissions, future stand-alone studies focusing on causal relationships with readmissions would be warranted. Once those factors are successfully identified, future TOC services may be designed to target the appropriate patient groups for whom they would be most effective.

Limitations

Our study was limited by several factors. First, the study used a nonrandomized design, selecting patients discharged from intervention and control hospitals. Although we matched the intervention and control populations using the number of prior hospitalizations and the LOS of the index hospitalization, the healthcare utilization in the intervention group was still higher than that of the control group, possibly indicating that the intervention group's health status was worse than that of the control group (Table 1). After controlling for these imbalances between the groups in the multivariate regression models, the intervention was still shown to have a significant impact on readmission rates. Second, the generalizability of our results may be limited because this study focused on the rural population of Bakersfield, California. Finally, an observational study cannot establish the causality of factors affecting the risk of readmission investigated in the current study. Future studies would be necessary to answer this research question.

CONCLUSIONS

Compared with usual discharge care, the ambulatory care pharmacy-based TOC program significantly reduced readmission rates by 28% at 30 days and 31.9% at 180 days. These are likely conservative estimates of the treatment effect, as all referred patients were included in the intent-to-treat analysis. ■

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of the manuscript for important intellectual content (WN, DC, JH, KK, CG, BW, JM); statistical analysis (WN, DC, JM); provision of patients or study materials (DC, JH, KK); obtaining funding (DC, JM); administrative, technical, or logistic support (DC, BW); and supervision (DC, JM).

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eAppendix

eAppendix Table A. Effects of Transitional Care on Count of Readmissions Estimated by OLS and Poisson Regressions[a]

	OLS Regression				Poisson Regression			
	Marginal Effects	**95% Confidence Limits**		***P***	**Marginal Effects**	**95% Confidence Limits**		***P***
30-Day	–0.0611	–0.104	–0.0178	0.006	–0.0562	–0.0962	–0.0162	.006
180-Day	–0.195	–0.321	–0.0680	0.003	–0.197	–0.298	–0.0973	<.001

OLS indicates ordinary least square

[a]Demographic information, comorbidities, and prior healthcare utilizations were controlled as in the logistic regressions to exclude effects from confounding factors.

eAppendix Table B. Estimated impact of patient's medical conditions and medication history on 30-day readmissions

Parameter	Odds Ratio	95% Confidence Interval		*P*
Hospital diagnoses				
Acute myocardial infarction	2.439	1.089	5.462	.0302
Arrhythmia, heart conduction disorders	0.507	0.105	2.46	.3994
Blood disease	1.380	0.491	3.883	.5416
Heart failure	1.225	0.568	2.643	.6054
Other disorders of the CNS	1.207	0.556	2.62	.6342
COPD and allied conditions	2.158	1.021	4.562	.0441
Diabetes	1.378	0.675	2.813	.3791
Digestive diseases	1.658	1.04	2.643	.0334
Endocrine disorders, non-diabetes	1.031	0.441	2.414	.943
Genitourinary diseases	1.174	0.666	2.069	.5793
Infectious and parasitic diseases	2.202	1.299	3.732	.0034
Injury and poisoning	1.495	0.917	2.438	.1072
Diseases of musculoskeletal system and connective tissue	1.230	0.628	2.409	.5459
Neoplasms	1.961	1.019	3.772	.0436
Other circulatory disease	1.628	0.931	2.846	.0871
Complications of pregnancy, childbirth	1.483	0.654	3.361	.3453
Respiratory disorders	0.611	0.298	1.253	.179
Skin and subcutaneous tissue diseases	1.504	0.736	3.073	.2634
Symptoms, signs, and ill-defined conditions	1.134	0.565	2.277	.7234
Medication classes				
Cardiovascular	0.704	0.473	1.048	.0836
Pulmonary	1.200	0.771	1.868	.4195
Diabetes	1.186	0.836	1.684	.3385
Psychotropic	0.882	0.623	1.249	.4806
Pain	0.985	0.639	1.519	.9463
Antiepileptic drugs	1.591	1.138	2.225	.0066
Anti-Parkinson's disease treatments	0.921	0.668	1.271	.6177
Gastrointestinal agents	0.943	0.638	1.394	.7688
Anti-infectives	1.051	0.727	1.518	.7914
Hormone replacement	0.593	0.287	1.224	.1575

Contraception	0.396	0.117	1.342	.1371
Male sexual dysfunction, benign prostatic hyperplasia treatment	1.188	0.524	2.696	.6799
Bladder/urinary treatment	1.242	0.867	1.78	.2378
Steroids (various uses)	0.983	0.63	1.532	.9392
Cough/cold, seasonal allergy medication	0.812	0.557	1.185	.2807
Cancer treatment	1.519	0.804	2.868	.1975
Dialysis solutions	1.734	1.181	2.545	.005
Dietary supplementation, including IV nutrition	1.531	1.085	2.162	.0153
Thyroid medication	1.346	0.876	2.069	.1749
Osteoporosis treatment	0.680	0.262	1.766	.4284
Dermatologic treatment	1.179	0.426	3.263	.7507
Ophthalmic treatment	1.113	0.283	4.379	.8788
Surgery preparations	0.914	0.634	1.318	.6312
Nicotine replacement therapy	1.086	0.415	2.846	.8662
Miscellaneous medical supplies	1.333	0.693	2.564	.3892

CNS indicates central nervous system; COPD, chronic obstructive pulmonary disease; IV, intravenous; ref, reference group;

eAppendix Table C. Estimated impact of patient's medical conditions and medication history on 180-day readmissions

Parameter	Odds Ratio	95% Confidence Interval		*P*
Hospital diagnoses				
Acute myocardial infarction	1.28	0.529	3.098	.5845
Blood disease	3.337	1.14	9.767	.0279
Heart failure	1.459	0.703	3.025	.3103
Other disorders of the CNS	1.345	0.649	2.79	.4257
COPD and allied conditions	2.865	1.436	5.716	.0028
Diabetes	2.3	1.188	4.453	.0135
Digestive diseases	1.09	0.688	1.728	.7136
Endocrine disorders, non-diabetes	1.534	0.768	3.065	.2255
Genitourinary diseases	0.799	0.475	1.345	.3984
Infectious and parasitic diseases	2.335	1.336	4.083	.0029
Injury and poisoning	1.334	0.828	2.148	.2359
Diseases of musculoskeletal system and connective tissue	0.898	0.479	1.683	.7372
Neoplasms	0.968	0.466	2.011	.9313
Other circulatory disease	1.099	0.639	1.89	.7324
Complications of pregnancy, childbirth	1.011	0.492	2.078	.9761
Respiratory disorders	0.828	0.439	1.561	.5595
Skin and subcutaneous tissue diseases	1.168	0.576	2.37	.6661
Symptoms, signs, and ill-defined conditions	0.591	0.286	1.222	.1561
Medication classes				
Cardiovascular	1.085	0.758	1.552	.6558
Pulmonary	0.892	0.59	1.348	.5866
Diabetes	1.199	0.853	1.687	.2967
Psychotropic	1.055	0.775	1.435	.7352
Pain	1.009	0.711	1.431	.9604
Antiepileptic drugs	1.042	0.768	1.413	.7933
Anti-Parkinson's disease treatments	0.98	0.73	1.317	.8948
Insomnia	0.879	0.587	1.315	.53
Gastrointestinal	1.088	0.767	1.543	.6367
Anti-infectives	0.844	0.608	1.173	.3131

Hormone replacement	0.89	0.494	1.603	.6987
Contraception	0.847	0.41	1.747	.652
Male sexual dysfunction, benign prostatic hyperplasia treatment	0.818	0.404	1.656	.5771
Bladder/urinary	1.359	0.565	3.266	.4931
Steroids (various uses)	0.684	0.269	1.741	.4255
Cough/cold, seasonal allergies	1.006	0.725	1.395	.9728
Dialysis solutions	1.611	1.127	2.302	.0088
Dietary supplementation, including IV nutrition	1.653	1.198	2.28	.0022
Osteoporosis treatment	1.157	0.765	1.749	.4896
Dermatologic treatment	0.558	0.165	1.881	.3465
Surgery preparations	0.572	0.297	1.101	.0944
Nicotine replacement therapy	0.9	0.339	2.391	.8331
Miscellaneous compounding ingredients	0.883	0.663	1.177	.3973

CNS indicates central nervous system; COPD, chronic obstructive pulmonary disease; IV, intravenous

eAppendix Table D. Estimated impact of patient's medical conditions and medication history on time-to-readmission

Parameter	Hazard Ratio	95% Confidence Interval		*P*
Hospital diagnoses				
Acute myocardial infarction	1.882	0.97	3.654	.0616
Arrhythmia, heart conduction disorders	0.556	0.132	2.338	.4235
Blood disease	1.276	0.525	3.098	.5904
Heart failure	1.184	0.604	2.319	.6231
Other disorders of the CNS	1.255	0.635	2.481	.5132
COPD and allied conditions	1.825	0.952	3.497	.0701
Diabetes	1.182	0.632	2.209	.6007
Digestive diseases	1.51	1.008	2.263	.0458
Endocrine disorders, non-diabetes	1.012	0.474	2.164	.9746
Genitourinary diseases	1.148	0.7	1.881	.5845
Infectious and parasitic diseases	1.955	1.246	3.068	.0035
Injury and poisoning	1.392	0.917	2.111	.1203
Diseases of musculoskeletal system and connective tissue	1.133	0.625	2.057	.6803
Neoplasms	1.65	0.939	2.9	.0816
Other circulatory disease	1.483	0.913	2.409	.1117
Complications of pregnancy, childbirth	1.348	0.642	2.83	.4306
Respiratory disorders	0.603	0.315	1.154	.1268
Skin and subcutaneous tissue diseases	1.381	0.74	2.575	.3106
Symptoms, signs, and ill-defined conditions	1.074	0.576	2.003	.8212
Medication classes				
Cardiovascular	0.703	0.49	1.009	.0557
Pulmonary	1.225	0.833	1.802	.3031
Diabetes	1.182	0.866	1.615	.2921
Psychotropic	0.911	0.665	1.248	.5615
Pain	0.998	0.673	1.479	.9916
Anti-epileptic drugs	1.516	1.122	2.047	.0067
Anti-Parkinson's disease treatments	0.918	0.689	1.225	.5629

Gastrointestinal agents	0.965	0.673	1.383	.8449
Anti-infectives	1.062	0.761	1.483	.7216
Hormone replacement	0.604	0.304	1.198	.149
Contraception	0.418	0.13	1.345	.1435
Male sexual dysfunction, benign prostatic hyperplasia treatment	1.176	0.588	2.351	.6467
Bladder/urinary treatment	1.187	0.862	1.635	.2926
Steroids (various uses)	0.957	0.643	1.424	.8283
Cough/cold, seasonal allergy medication	0.86	0.614	1.204	.3801
Cancer treatment	1.351	0.783	2.328	.2794
Dialysis solutions	1.665	1.192	2.327	.0028
Dietary supplementation, including IV nutrition	1.453	1.071	1.972	.0165
Thyroid medication	1.33	0.915	1.935	.135
Osteoporosis treatment	0.761	0.327	1.771	.5264
Dermatologic treatment	1.27	0.534	3.018	.5885
Ophthalmic treatment	1.22	0.363	4.102	.7485
Surgery preparations	0.901	0.649	1.249	.5306
Nicotine replacement therapy	1.098	0.482	2.504	.8239
Miscellaneous medical supplies	1.25	0.707	2.21	.4425

IV indicates intravenous.