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A transition care coordinator model reduces hospital readmissions and costs

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ABSTRACT

Background: The optimal structure and intensity of interventions to reduce hospital readmission remains uncertain, due in part to lack of head-to-head comparison. To address this gap, we evaluated two forms of an evidence-based, multi-component transitional care intervention.
Methods: A quasi-experimental evaluation design compared outcomes of Transition Care Coordinator (TCC) Care to Usual Care, while controlling for sociodemographic characteristics, comorbidities, readmission risk, and administrative factors. The study was conducted between January 1, 2013 and April 30, 2015 as a quality improvement initiative. Eligible adults ($N = 7038$) hospitalized with pneumonia, congestive heart failure, or chronic obstructive pulmonary disease were identified for program evaluation via an electronic health record algorithm. Nurse TCCs provided either a full intervention (delivered in-hospital and by post-discharge phone call) or a partial intervention (phone call only).
Results: A total of 762 hospitalizations with TCC Care (460 full intervention and 302 partial intervention) and 6276 with Usual Care was examined. In multivariable models, hospitalizations with TCC Care had significantly lower odds of readmission at 30 days (OR = 0.512, 95% CI 0.392 to 0.668) and 90 days (OR = 0.591, 95% CI 0.483 to 0.723). Adjusted costs were significantly lower at 30 days (difference = $3969, 95% CI $5099 to $2691) and 90 days (difference = $5684, 95% CI $7602 to $3627). The effect was similar whether patients received the full or partial intervention.
Conclusion: An evidence-based multi-component intervention delivered by nurse TCCs reduced 30- and 90-day readmissions and associated health care costs. Lower intensity interventions delivered by telephone after discharge may have similar effectiveness to in-hospital programs.

1. Introduction

Reducing hospital readmissions remains a national priority, stimulated by payment reform, financial penalties, and value-based care [1–3]. Health systems have implemented myriad approaches to prevent readmissions [4,5]. However, progress remains modest, with recent multi-center studies showing a reduction in readmissions of only 1–2 percentage points compared to controls [6]. Little research has directly compared transitional care interventions that have different levels of intensity or modes of delivery, and thus, the optimal structure and intensity needed to improve outcomes remains uncertain.

The Ideal Transition in Care (ITC) is an evidence-based framework which synthesizes the elements of multiple transitional care interventions that have demonstrated efficacy or effectiveness in published research studies [7]. It provides one of the best available guides for designing interventions in this context. The ITC outlines 10 domains related to discharge planning, information transfer, medication safety, patient education and engagement, coordination of care, and outpatient follow-up, to foster a safe and effective transition from hospital to home. In a systematic review which mapped elements of transitional

Abbreviations: ITC, Ideal Transition in Care; TCC, Transition Care Coordinator

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care programs to the ITC framework, interventions that addressed a greater number of ITC domains were more effective in reducing hospital readmission, thus validating the framework [8]. To our knowledge, interventions based prospectively on the ITC framework have not been evaluated. Here we describe a multi-component transitional care intervention based on the ITC model and evaluate its effectiveness in reducing 30-day and 90-day hospital readmission and costs. Additionally, we compare two forms of the intervention which differed in intensity and mode of delivery.

2. Methods

2.1. Setting and population

The study was performed at Vanderbilt University Medical Center in Nashville, TN, as part of a quality improvement initiative funded by a Health Care Innovation Award from the Centers for Medicare and Medicaid Services Innovation (CMMI) Center. The intervention targeted patients hospitalized for pneumonia (PNA), congestive heart failure exacerbation (CHF), or chronic obstructive pulmonary disease exacerbation (COPD), corresponding to readmission penalty diagnoses; patients with acute myocardial infarction were not included due to another ongoing intervention for that group. Eligible patients were hospitalized in either inpatient or observation status, between January 1, 2013 and April 30, 2015. Participants were identified through two complementary strategies according to whether they received a "full" intervention which included both in-hospital and post-discharge components, or a "partial" intervention which included only post-discharge telephone-based contact (described below).

For the full intervention, patients were identified early during their hospitalization through chart screening performed by experienced nurses who served as Transition Care Coordinators (TCCs). Chart review was necessary to determine the primary clinical condition driving hospital admission and due to the absence of billing data early in the patients' hospital stay. The TCCs focused screening on medical services most likely to care for these patient diagnoses, including general internal medicine, hospital medicine, geriatrics, cardiology, pulmonary, infectious diseases, and medical intensive care unit (ICU) services. Mechanically ventilated or other ICU patients were not enrolled initially, but were followed and approached for enrollment as their clinical condition improved.

The partial intervention was added after an initial program evaluation showed that not all potentially eligible patients were being picked up by the real-time screening methods. For example, patients hospitalized on other services or discharged before chart screening could be completed were missed. Additional post-discharge screening was introduced, in which TCCs reviewed lists of patients recently discharged from any hospital service with a final diagnosis of PNA, CHF, or COPD (according to the billing codes used for CMS tracking), and reached out by telephone if they had not been seen in the hospital. Introducing this approach in the quality improvement initiative also provided an opportunity to test the effectiveness of a process that was more efficient for patient identification and required less staff time for intervention.

All adults were eligible, though Medicare beneficiaries were prioritized. Patients were excluded for any of the following: police custody, homelessness, unstable psychiatric condition (e.g., acute psychosis), hospice care, participation in a conflicting study, ventilator-associated pneumonia, or disease outlier (e.g., heart transplantation candidate).

2.2. Usual Care

In usual care, the treating physicians and nurses performed discharge planning (without a structured needs assessment), medication reconciliation, and patient education according to standard hospital procedures. Case managers, social workers, and clinical pharmacists screened some patients and were available to assist patients on request. At the time, the hospital's efforts related to readmissions included staff education on discharge planning and communication, as well as tools in the electronic health record to facilitate medication reconciliation and discharge summary communication. Patients did not receive standardized phone calls after discharge. At the time of study, no other disease-specific readmission reduction initiatives were in place for patients with the target conditions.

2.3. Intervention

Experienced Registered Nurses were trained as Transition Care Coordinators (TCCs), a role designed to supplement usual care by coordinating delivery of interventions based on the ITC model. TCCs identified eligible patients as soon as feasible after admission, engaged patients early to anticipate needs at discharge, and led daily transition huddles with inpatient clinical teams to coordinate delivery of evidence-based interventions tailored to each patient's needs. The five main components of the full TCC intervention were: [1] Structured needs assessment; [2] Medication reconciliation; [3] Patient education; [4] Anticipatory post-discharge guidance and contingency plan; and [5] Facilitated follow-up. They covered 7 of 10 domains in the ITC framework: discharge planning, medication safety, educating patients to promote self-management, enlisting help of social and community supports, coordinating care among team members, monitoring and managing symptoms after discharge, and outpatient follow-up [7].

The structured needs assessment identified modifiable barriers, facilitating early discharge planning and prioritization of services [9]. TCCs performed a detailed review and reconciliation of medications. At the time of discharge, TCCs provided patient education, supplemented with clear and patient-friendly medication instructions, and involved clinical pharmacists for additional medication counseling for patients with complex or high-risk medication regimens. TCCs discussed problems that could arise and what to do if they occurred. After discharge, TCCs performed a structured phone call to assess symptoms that required additional management, review medications, reinforce education, confirm follow-up appointments, and resolve pending items (e.g., test results, home services). Additional calls were made if needed to resolve problems.

In the partial intervention, TCCs did not perform the structured needs assessment or in-depth medication reconciliation. However, via telephone, they did screen for new or worsening symptoms, review medications, educate patients about discharge diagnoses, provide anticipatory guidance, and confirm follow-up and pending items.

2.4. Study design and samples for evaluation

A retrospective, quasi-experimental program evaluation compared outcomes among program participants to concurrent non-participants receiving usual care. The program evaluation was reviewed and determined exempt by the Vanderbilt University IRB under the criterion of quality improvement.

For purposes of program evaluation we retrospectively developed an algorithm to reflect the eligible patient population, and we used this algorithm to define intervention and control samples for comparison. The algorithm included patients age 18 or older, in either observation or inpatient status, who had either a principal diagnosis code for one of the conditions of interest (PNA, CHF, or COPD, according to ICD-9 code definitions used by CMS), or a combination of primary and secondary diagnoses that likely indicated a condition of interest. For example, patients hospitalized with pneumonia and sepsis were often coded with a principal discharge diagnosis of sepsis and a secondary diagnosis of pneumonia; we classified this combination in our algorithm as having pneumonia.

The intervention group was defined as patients hospitalized between January 1, 2013 and April 30, 2015; who were identified in the

Table 1
Characteristics of hospitalizations receiving Usual Care and TCC Care.

	Usual Care $N = 6276$	TCC Care $N = 762$	TCC (Full) $N = 460$	TCC (Partial) $N = 302$
Patient characteristics				
Age at admission				
Mean (SD)	62.2 (16.9)	64.0 (13.9)	66.4 (12.8)	60.2 (14.6)
≥65 Yrs	2960 (47.2%)	373 (49.0%)	254 (55.2%)	119 (39.4%)
Sex, Male	3291 (52.4%)	384 (50.4%)	222 (48.3%)	162 (53.6%)
Marital status				
Single	1458 (23.2%)	180 (23.6%)	104 (22.6%)	76 (25.2%)
Married	2959 (47.1%)	358 (47.0%)	206 (44.8%)	152 (50.3%
Divorced/Separated	860 (13.7%)	103 (13.5%)	61 (13.3%)	42 (13.9%)
Widowed	949 (15.1%)	116 (15.2%)	86 (18.7%)	30 (9.9%)
None/Unknown	50 (0.8%)	5 (0.7%)	3 (0.7%)	2 (0.7%)
Race				
African-American	1206 (20.0%)	152 (19.9%)	95 (20.7%)	57 (18.9%)
Asian	41 (0.7%)	2 (0.3%)	0 (0%)	2 (0.7%)
Caucasian	4787 (76.3%)	587 (77.0%)	355 (77.2%)	232 (76.8%)
Other/Missing	101 (1.7%)	11 (1.4%)	5 (1.1%)	6 (2.0%)
Ethnicity, Hispanic	81 (1.3%)	10 (1.3%)	5 (1.1%)	5 (1.7%)
Health literacy, mean (SD)	11.6 (3.5)	11.6 (3.3)	11.4 (3.4)	11.9 (3.3)
Insurance				
Medicare fee-for-service	2802 (44.6%)	311 (40.8%)	197 (42.8%)	114 (37.7%)
Medicare Advantage	1204 (19.2%)	174 (22.8%)	111 (24.1%)	63 (20.9%)
Medicaid	43 (0.7%)	6 (0.8%)	2 (0.4%)	4 (1.3%)
Commercial	1764 (28.1%)	213 (28.0%)	115 (25.0%)	98 (32.5%)
Uninsured	463 (7.4%)	58 (7.6%)	35 (7.6%)	23 (7.6%)
Zip code location				
Local-Nashville	1543 (24.6%)	219 (28.7%)	147 (32.0%)	72 (23.8%)
Regional-Nashville	1400 (22.3%)	155 (20.3%)	98 (21.3%)	57 (18.9%)
Other	3333 (53.1%)	388 (50.9%)	215 (46.7%)	173 (57.3%)
Type of admission				
Emergency	4737 (75.5%)	656 (86.1%)	399 (86.7%)	257 (85.1%)
Urgent	1297 (20.7%)	101 (13.3%)	58 (12.6%)	43 (14.2%)
Elective	242 (3.9%)	5 (0.7%)	3 (0.7%)	2 (0.7%)
Source of admission				
Self	3803 (60.6%)	537 (70.5%)	336 (73.0%)	201 (66.6%)
Provider	853 (13.6%)	101 (13.3%)	56 (12.2%)	45 (14.9%)
Transfer	1478 (23.5%)	123 (16.1%)	67 (14.6%)	56 (18.5%)
Nursing home/hospice	142 (2.3%)	1 (0.1%)	1 (0.2%)	0 (0%)
Clinical variables				
Target conditions				
CHF	3150 (50.2%)	253 (33.2%)	161 (35.0%)	92 (30.5%)
COPD	779 (12.4%)	159 (20.9%)	107 (23.3%)	52 (17.2%)
Pneumonia	2347 (37.4%)	350 (45.9%)	192 (41.7%)	158 (52.3%)
Comorbidity				
Elixhauser Index				
Mean (SD)	22.19 (11.9)	18.74 (12.0)	17.79 (11.8)	20.20 (12.2)
Risk of hospital readmission				
LACE score				
Mean (SD)	12.66 (4.53)	11.65 (4.58)	11.31 (4.50)	12.17 (4.64)
Median (IQR)	12 (9,16)	12 (8,15)	11 (8,15)	12 (9,16)
≥10	4602 (73.3%)	492 (64.5%)	286 (62.2%)	206 (68.2%)
Administrative variables				
Hospital length of stay, mean (SD)	6.11 (6.39)	4.05 (3.48)	3.89 (3.21)	4.29 (3.84)
Season at discharge				
Winter	2178 (34.7%)	246 (32.3%)	128 (27.8%)	118 (39.1%)
Spring	1508 (24.0%)	219 (28.7%)	114 (24.8%)	105 (34.8%)
Summer	1217 (19.4%)	116 (15.2%)	83 (18.0%)	33 (10.9%)
Fall	1373 (21.9%)	181 (23.8%)	135 (29.3%)	46 (15.2%)
ED visits in prior 6 months				
Mean (SD)	0.23 (0.88)	0.20 (0.60)	0.19 (0.60)	0.21 (0.59)
0	5359 (85.4%)	662 (86.9%)	404 (87.8%)	258 (85.4%)
1	636 (10.1%)	69 (9.1%)	38 (8.3%)	31 (10.3%)
2	178 (2.8%)	17 (2.2%)	8 (1.7%)	9 (3.0%)
3	55 (0.9%)	11 (1.4%)	8 (1.7%)	3 (1.0%)
≥4	48 (0.8%)	3 (0.4%)	2 (0.4%)	1 (0.3%)
Type of hospitalization				
Inpatient	5723 (91.2%)	706 (92.7%)	405 (88.0%)	301 (99.7%)
Observation	553 (8.8%)	56 (7.3%)	55 (12.0%)	1 (0.3%)
Hospitalizations in prior 6 months				
Mean (SD)	0.47 (0.90)	0.30 (0.71)	0.25 (0.54)	0.37 (0.91)
0	4366 (69.6%)	602 (79.0%)	367 (79.8%)	235 (77.8%)
1	1246 (20.6%)	118 (15.5%)	76 (16.5%)	42 (13.9%)
2	431 (8.8%)	27 (3.5%)	13 (2.8%)	14 (4.6%)

(*continued on next page*)

Table 1 (*continued*)

	Usual Care N = 6276	TCC Care N = 762	TCC (Full) N = 460	TCC (Partial) N = 302
3	146 (3.9%)	11 (1.4%)	4 (0.9%)	7 (2.3%)
4	87 (2.6%)	4 (0.6%)	0 (0%)	4 (1.3%)
Related admission in prior 30 days	1076 (17.1%)	95 (12.5%)	51 (11.1%)	44 (14.6%)
Care coordination by cardiology clinic staff	319 (5.1%)	86 (11.3%)	33 (7.2%)	53 (17.5%)
Medical service at discharge				
Hospitalist[a]	686 (10.9%)	186 (24.4%)	153 (33.3%)	33 (10.9%)
General Internal Medicine	908 (14.5%)	154 (20.2%)	113 (24.6%)	41 (13.6%)
Cardiology	994 (15.8%)	94 (12.3%)	55 (12.0%)	39 (12.9%)
Pulmonary	827 (13.2%)	113 (14.8%)	73 (15.9%)	40 (13.2%)
Heart failure	1174 (18.7%)	59 (7.7%)	26 (5.7%)	33 (10.9%)
Geriatrics	505 (8.0%)	59 (7.7%)	36 (7.8%)	23 (7.6%)
Oncology	344 (5.5%)	24 (3.1%)	0 (0%)	24 (7.9%)
Infectious diseases	231 (3.7%)	19 (2.5%)	0 (0%)	19 (6.3%)
Nephrology	208 (3.3%)	17 (2.2%)	0 (0%)	17 (5.6%)
Primary care physician[a]	102 (1.6%)	12 (1.6%)	1 (0.2%)	11 (3.6%)
Malignant hematology[a]	102 (1.6%)	11 (1.4%)	1 (0.2%)	10 (3.3%)
Malignant hematology	102 (1.6%)	9 (1.2%)	2 (0.4%)	7 (2.3%)
Bone marrow transplant	77 (1.2%)	4 (0.5%)	0 (0%)	4 (1.3%)
Sickle cell[a]	16 (0.3%)	1 (0.1%)	0 (0%)	1 (0.3%)
Payment in the 3 days prior to admission, mean (SD)	$289 ($1813)	$197 ($1444)	$240 ($1641)	$131 ($1076)

Values represent N (%) unless otherwise specified.
[a] Indicates services without trainees.

electronic health record by the above algorithm; and who received either the full or partial intervention by a TCC as reflected by their documentation logs. The usual care control group was hospitalized during the same date range and identified by the same algorithm, but did not receive the TCC intervention, usually for operational reasons (e.g., TCCs were unable to get to the patient).

Only patients discharged to home were included in the evaluation; we excluded patients who died in the hospital, left against medical advice, or were transferred to another acute care or post-acute care facility. We also excluded extremely complex cases that might have skewed the evaluation (e.g., length of stay > 120 days, patient with > 4 hospitalizations during the study period).

2.5. Data collection and analysis

Patient demographics, insurance, comorbidities, admission source, discharge disposition, health care utilization (ED visits and hospitalizations), and payment data were extracted from the electronic health record and administrative databases. TCCs prospectively documented intervention delivery in REDCap [10].

For the 30 days (primary) and 90 days after discharge, we calculated unadjusted rates of readmission, ED visits, mortality, charges, and payments for the Usual Care, TCC Care (overall), TCC full intervention, and TCC partial intervention groups. We used regression analyses to compare the impact of the TCC intervention against usual care while adjusting for confounding variables including patient age, race, gender, marital status, insurance, zip code, health literacy (screened routinely at the study hospital) [11], primary disease class, Elixhauser comorbidity index [12], the LACE readmission risk score which is commonly used in research and operations [13], type and source of admission, hospital length of stay, medical service at discharge, number of admissions in the prior 6 months, admission related to the diagnosis in the prior 30 days, receipt of care coordination by cardiology clinic staff (a pre-existing initiative provided to some heart failure patients), total charges in the prior 3 days, quarterly season of calendar year of hospital discharge, and a cumulative time variable accounting for the number of calendar quarters since the start-up of the TCC program. We imputed missing data and introduced an indicator variable for a covariate (health literacy) with substantive missingness.

The level of analysis was at the hospitalization whereby a patient could have intervention and usual care hospitalizations across the study period. We used Generalized Estimating Equation (GEE) methods (with the independent working correlation structure) to account for within-patient correlation [14]. Type I error was controlled at a level of 0.05, and Wald tests with robust sandwiches variance estimators tested the statistical significance of the coefficients of the covariates [15]. Hospital readmissions (binary outcome data) were modeled with a GEE model that used a logit link function with each patient as a cluster. To test for effect modification, we evaluated the significance of interaction terms with the following variables in separate models: type of intervention (full vs partial), patient age, health literacy, LACE score, and diagnosis (CHF, COPD, or pneumonia). Owing to multiple comparisons, we applied the Bonferroni correction.

Costs of care after discharge were assessed according to hospital charges (hospital perspective) as well as insurance payments (societal cost perspective). Cost outcomes were modeled using two-part models due to excessive zero cost [16,17]. Part one, a logistic model, accounted for post-discharge periods having zero cost (29.5% of hospital discharges). Part two conditionally modeled discharges having cost using (zero-truncated) Poisson regression. Again for both parts, we fit GEE models with each patient considered as a cluster, and adjusted for the confounding variables listed above. The two parts were combined to model cost differences, and 95% confidence intervals were estimated with 1000 bootstraps. We performed a sensitivity analysis on 30-day costs which excluded patient hospitalizations having extremely high cost (> 95th percentile).

3. Results

There were 7132 hospitalizations with Usual Care and 844 hospitalizations with TCC Care. Overall 26% of the included patients had more than one hospitalization. After limiting to patients with at most four hospitalizations, the analytic sample included 6276 hospitalizations with Usual Care and 762 with TCC Care. Among TCC Care, 460 patient hospitalizations received the full intervention, and 302 received the partial intervention (post-discharge only).

Overall, most characteristics were similar between the Usual Care and TCC Care groups (Table 1). The TCC Care group had a greater percentage of patients with pneumonia or COPD and less with CHF. Among TCC Care patients, emergency admission was more common, and they were less likely to be transferred from another hospital. The TCC Care group had lower mean Elixhauser comorbidity and LACE

Table 2
Unadjusted rates of health care utilization, mortality, and costs over 30 and 90 days in TCC Care vs. Usual Care.

	Usual Care *N* = 6276	TCC Care *N* = 762	TCC (Full) N = 460	TCC (Partial) N = 302	*P*-value (Usual Care vs. TCC Care)
Readmissions					
30-day	1182 (18.8%)	72 (9.4%)	41 (8.9%)	31 (10.3%)	< 0.001
90-day	1975 (31.5%)	151 (19.8%)	86 (18.7%)	65 (21.5%)	< 0.001
Emergency Department visits					
30-day	256 (4.1%)	23 (3.0%)	15 (3.3%)	8 (2.6%)	0.187
90-day	531 (8.5%)	55 (7.2%)	31 (6.7%)	24 (7.9%)	0.270
Mortality post-discharge					
30-day	93 (1.5%)	4 (0.5%)	1 (0.3%)	3 (0.7%)	0.048
90-day	244 (3.9%)	12 (1.6%)	5 (1.7%)	7 (1.5%)	0.002
Charges post-discharge					
30-day					< 0.001
Mean (SD)	$24,794 ($91,606)	$9481 ($36,704)	$9628 ($43,612)	$9258 ($22,480)	
25,50,75 quantiles	$0, $1193, $13,279	$0, $715, $3529	$0, $584, $2498	$0, $1121, $6665	
90-day					< 0.001
Mean (SD)	$51,456 ($138,131)	$23,812 ($53,629)	$20,289 ($52,029)	$29,178 ($55,639)	
25,50,75 quantiles	$637, $5862, $46,424	$284, $3146, $23,617	$0, $2442, $16,191	$668, $5316, $32,231	
Payments					
30-day					< 0.001
Mean (SD)	$7994 ($35,500)	$2467 ($9376)	$2308 ($9508)	$2710 ($9181)	
25,50,75 quantiles	$0, $267, $2635	$0, $192, $784	$0, $171, $669	$0, $233, $1051	
90-day					< 0.001
Mean (SD)	$15,721 ($45,778)	$6942 ($17,384)	$5346 ($13,074)	$9373 ($22,217)	
25,50,75 quantiles	$123, $1156, $13,082	$11, $668, $5038	$0, $579, $3139	$129, $963, $10,132	

scores, shorter index length of stay, fewer hospitalizations in the prior 6 months and prior 30 days, and lower costs in the 3 days prior to admission. The TCC full and partial groups were also similar in many characteristics, except for age, marital status, zip code location, diagnosis, inpatient/observation status, cardiology care coordination, and medical service and season at discharge (Table 1).

As shown in Table 2, encounters with TCC Care had significantly lower unadjusted rates of readmission at 30 days (9.4% for overall TCC Care vs. 18.8% for Usual Care) and 90 days (19.8% vs. 31.5%), $p < 0.001$ for each comparison. With TCC Care, mortality was lower at 30 days (0.5% vs. 1.5%) and 90 days (1.6% vs. 3.9%), though the number of events was small. Total unadjusted post-discharge costs were significantly lower for TCC Care at 30 days (mean payment = $2467 vs. $7994) and 90 days (mean payment = $6942 vs. $15,721), $p < 0.001$. Emergency Department visits not leading to admission were similar between Usual Care and TCC Care. The full and partial TCC groups had similar unadjusted outcomes.

In multivariable analyses (Table 3), patient hospitalizations receiving TCC Care had significantly lower odds of readmission at 30 days (OR = 0.512, 95% CI 0.392 to 0.668) and 90 days (OR = 0.591, 95% CI 0.483 to 0.723), compared to Usual Care. The effect was similar whether patients received the full or partial intervention ($p = 0.679$ and $p = 0.746$ for the interaction term of intervention type at 30 and 90 days, respectively). Compared to Usual Care, patients who received the full TCC intervention had lower odds of readmission at 30 days (OR = 0.536, 95% CI 0.381 to 0.753) and 90 days (OR = 0.607, 95% CI 0.468 to 0.786); patients who received the partial TCC intervention (post-discharge only) had lower odds of readmission at 30 days (OR = 0.482, 95% CI 0.326 to 0.713) and 90 days (OR = 0.569, 95% CI 0.422 to 0.769).

Table 3
Adjusted effect of TCC Care on readmissions at 30 and 90 days.

	TCC Care (Overall)	TCC (Full)	TCC (Partial)
30-day	0.512 (0.392, 0.668)	0.536 (0.381, 0.753)	0.482 (0.326, 0.713)
90-day	0.591 (0.483, 0.723)	0.607 (0.468, 0.786)	0.569 (0.422, 0.769)

Values represent Odds Ratio (95% Confidence Interval) of the intervention (overall, in full format, and in partial format) compared to Usual Care.

Heterogeneity of treatment effect was observed according to readmission risk, such that the intervention effect appeared greater among encounters with lower LACE score. At 30 days, OR = 0.285, 0.401, or 0.565 when LACE = 5, 10, or 15, respectively. At 90 days, OR = 0.357, 0.487, or 0.655, when LACE = 5, 10, or 15, respectively. Effect modification was not present by patient age, health literacy, or diagnosis. For example, for 90-day readmissions, the full TCC intervention had OR = 0.610 in CHF, OR = 0.563 in COPD, and OR = 0.584 in PNA, compared to usual care.

Adjusted analyses for societal costs of care (i.e., payments) at 30 days were lower with TCC Care by $3969 (95% CI $2691 to $5099). At 90 days, costs were lower with TCC Care by $5684 (95% CI $3627 to $7602) (Table 4). In sensitivity analyses which excluded patients with the highest cost, TCC Care hospitalizations had lower costs at 30 days (difference $933, 95% CI $593 to $1263) and 90 days ($2296, 95% CI $826 to $3574). The estimated costs for patients in the TCC partial intervention and TCC full intervention groups were similar, with both the 95% CIs for differences at 30 days and at 90 days overlapping 0.

4. Discussion

A multi-component, evidence-based intervention delivered by nurse Transition Care Coordinators (TCCs) was effective in reducing 30- and 90-day readmissions and associated health care costs. The intervention components were guided by the Ideal Transition in Care framework [7] and included a structured assessment of patients' transitional care needs to facilitate early discharge planning, medication reconciliation, patient education, anticipatory guidance, and follow-up. Importantly, we found that a less intensive form of the intervention, delivered via telephone post-discharge, was also effective.

Many interventions for reducing hospital readmission have been described in the literature, with varying levels of success [4,18]. Classic models include the Care Transitions Initiative (CTI) [19], Project Re-engineering Discharge (RED) [20], and Comprehensive Discharge Planning (CDP) [21]. The present initiative took a patient-centered approach and shared several features in common with these classic programs, including use of a dedicated individual to “own” the process,

Table 4
Adjusted effect of TCC Care on total post-discharge costs at 30 and 90 days using a two-part model.

30 day	Usual Care	TCC Care (Overall)	Difference (95% CI)	TCC (Full)	TCC (Partial)	Difference (95% CI)
Percent with cost > 0	70.8%	67.7%	2.9%	67.3%	68.4%	−1.1%
Estimated Total Cost given cost > 0	$10,074	$4999	$5075	$5859	$4200	$1659
Estimated Total Cost	$7601	$3632	$3969 (> $2589, $5099)	$4236	$3078	$1158 (−$690, $3268)
90 day						
Percent with cost > 0	79.3%	76.0%	3.3%	74.7%	78.4%	−3.7%
Estimated Total Cost given cost > 0	$18,033	$11,653	$6380	$11,595	$11,703	-$108
Estimated Total Cost	$15,123	$9439	$5684 ($3627, $7602)	$9250	$9716	-$466 (−$3636, $3079)

a structured transitional care needs assessment which included attention to social determinants of health, patient education about the condition and medications, and telephone follow-up to address issues related to symptoms, medications, and appointments. These commonalities point to what are probably the key ingredients of a successful transitional care intervention, as also supported by the results of a review that mapped components of successful interventions to the ITC framework [8]. Focusing on these elements could help reduce the great variation seen in the implementation of hospital readmission reduction programs [22,23] and may improve their effectiveness.

We demonstrated a sustained effect over a 90-day period, which the CTI and CDP also achieved [19,24]. Notably, both of these interventions involved in-home visits, whereas ours did not. The extended benefit of the CTI model was attributed to health coaching. While the TCCs in our initiative did not provide the same degree of health coaching, they did provide patient education and anticipatory guidance about how to handle problems, and we expect these features contributed to the longer-term benefit.

Interestingly, we observed heterogeneity of treatment effect according to level of readmission risk. Patients with *lower* predicted readmission risk had *greater* odds of benefitting from the intervention. Initially this may seem counterintuitive, but patients with lower calculated risk may actually have more intervenable factors. Conversely, patients with a high predicted risk of readmission may be so ill that transitional care interventions (which focus more on social, behavioral, and logistical factors) provide less assistance. This is not to say, however, that hospitals should focus on lower risk patients. The number needed to treat (NNT) to prevent 1 readmission is higher among lower risk patients. For this intervention, among patients with a LACE index of 5 (which corresponds to a 5% readmission risk) [13], the NNT is approximately 28; at a LACE index of 10 (12% readmission risk), the NNT is 14; and at a LACE index of 15 (27% readmission risk), the NNT is 9. Additional research is needed on heterogeneity of treatment effects and NNT of transitional care interventions. Such information would provide valuable guidance for health systems on how to best allocate resources [25,26]. The LACE score is easily calculated and well-suited for this purpose. Numerous other risk prediction scores are available for general and disease-specific use [27], or for prediction of preventable readmissions [28]. However, many of these tools are more complex, which could impede their use operationally, and they all have only modest ability to predict readmission [27].

We introduced a partial intervention delivered by telephone post-discharge, after recognizing the difficulty of accurately identifying patients during their hospitalization who would go on to be coded with a principal diagnosis of pneumonia, COPD, or CHF. This adaptation to the quality improvement initiative enabled us to assist a greater number of eligible patients, even if not with the full intervention. Indeed, patients for the post-discharge intervention were identified much more efficiently, through the use of automated reports sent to the project team 2–3 days after discharge. The amount of time spent with each patient was substantially less, approximately 30–45 min, compared to 2–4 h with the full intervention. Although we expected to find reduced benefit in this partial intervention group, the results demonstrated its effect was not significantly different than that of the full intervention. This approach may represent a much more efficient use of resources and should be replicated to confirm our findings.

The cost to implement the intervention consists of salary and benefits for a nurse Transition Care Coordinator, which was $78,552 annually. During the 28-month implementation period, the project employed 1–3 TCCs at a time, who collectively had a total of 8525 paid hours and incurred a total cost of $321,963. The TCCs were involved in the care of 844 patients, yielding a cost per patient of $381. The cost savings per patient with TCC Care was estimated at $3969 at 30 days and $5684 at 90 days, indicating a return on investment from a societal perspective of 10:1 at 30 days and 15:1 at 90 days. In the sensitivity analysis which removed the highest cost patients, the return on investment was 2.5:1 at 30 days and 6:1 at 90 days, which remains favorable.

Several limitations were present. First, the TCC intervention was delivered as a quality improvement initiative. Thus, the analysis relied on retrospective approach to define intervention and control samples using the same case finding algorithm. The Usual Care and TCC Care groups were similar in most respects, and we performed careful statistical adjustment to account for factors that differed between the groups. Nevertheless, the possibility of residual confounding cannot be excluded. Second, the results reported here are from a single academic medical center, and the outcome data are limited to that institution. Third, because the intervention was delivered as a bundle, we are unable to determine which component, if any, was most impactful. Fourth, although the 30- and 90-day mortality rates appeared to be lower in the intervention group, the small number of events limits the ability to draw firm conclusions. Finally, the initiative focused on patients admitted with certain medical conditions tracked by the funding agency, CMS. However, the only disease-specific aspect of the intervention was patient education; we believe the approach is generalizable and could extend to other medical conditions.

In conclusion, we determined that a multi-component transitions of care intervention was effective in reducing hospital readmission and costs at both 30 and 90 day follow-up. Additional research is needed to confirm if the more efficient model of post-discharge intervention has similar effectiveness to the full model.

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