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Which Readmissions May Be Preventable? Lessons Learned from a Post-Hospitalization Care Transitions Program for High Risk Elders

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Abstract

Background—Care transitions programs have been shown to reduce hospital readmissions.

Objectives—Evaluate effects of the Mayo Clinic Care Transitions program (MCCT) on potentially preventable and non-preventable 30-day unplanned readmissions among high risk elders.

Research Design—Retrospective cohort study of patients enrolled in MCCT following hospitalization and propensity score-matched controls receiving usual primary care.

Subjects—Primary care patients ≥ 60 years, at high risk for readmission, hospitalized for any cause between January 1, 2011 and June 30, 2013.

Measures—30-day hospital readmission. The 3M™ algorithm was used to identify potentially preventable readmissions. Readmissions for ambulatory care sensitive conditions (ACSCs), a subset of preventable readmissions identified by the 3M algorithm, were also assessed.

Results—The study cohort included 365 pairs of MCCT enrollees and propensity score-matched controls. Patients were similar in age (mean 83 years) and other baseline demographic and clinical characteristics, including reason for index hospitalization. MCCT enrollees had a significantly lower all-cause readmission rate (12.4% [95% CI, 8.9–15.7] vs. 20.1% [15.8–24.1]; p=0.004) resulting from a decrease in potentially preventable readmissions (8.4% [95% CI, 5.5–11.3] vs.

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14.3% [95% CI, 10.5–17.9]; $p=0.01$). Few potentially preventable readmissions were for ACSCs (6.7% vs. 12.0%). The rates of non-potentially preventable readmissions were similar (4.3% [95% CI, 2.2–6.5] vs. 6.7% [95% CI, 4.0–9.4]; $p=0.16$). Potentially preventable readmissions were reduced by 44% (HR 0.56; 95% CI, 0.36–0.88; $p=0.01$) with no change in other readmissions.

Conclusions—The MCCT significantly reduces preventable readmissions, suggesting that access to multi-disciplinary care can reduce readmissions and improve outcomes for high risk elders.

Keywords

care transitions; health sciences research; discharge planning; health care quality; readmission; geriatrics; ambulatory care sensitive conditions

INTRODUCTION

Hospitalized older patients with multiple or complex comorbidities face a high risk of hospital readmission.^{1, 2} Such readmissions incur high personal and societal burden, yet many may be avoided with optimal inpatient, transitional, and post-discharge ambulatory care.³ To reduce readmissions, a variety of care transitions programs have been implemented across the U.S.,^{4–6} including at our institution.^{7, 8} The Mayo Clinic Care Transitions program (MCCT), a multi-disciplinary program targeting hospitalized medically-complex older adults at high risk for readmission or emergency department use, reduces readmission rates by nearly 50% during the 30-day duration of the program.^{7, 8} However, not all readmissions could be avoided and more nuanced understanding of the types of readmissions that could and could not be prevented by the MCCT may help improve this program and others like it. Characterizing potentially preventable readmissions is the first step toward prospective identification of high risk patients who may be most likely to benefit from targeted interventions.

Condition-specific and all-cause unplanned 30-day readmission rates are measured, publicly reported, and considered by the Centers for Medicare and Medicaid Services (CMS) for performance-based reimbursement because they reflect the quality of inpatient, transitional, and ambulatory care. However, not all hospital readmissions can be prevented. Some are planned, and CMS has developed a widely used algorithm to identify planned readmissions.^{9, 10} The Agency for Healthcare Research and Quality (AHRQ) defined acute and chronic ambulatory care sensitive conditions (ACSCs),¹¹ which ought to be addressed and treated in the outpatient setting and not require hospitalization. An algorithm developed by 3MTM identifies potentially preventable medical and surgical readmissions, defined as either being related to the index hospitalization (and thus avoidable with optimal inpatient and/or transitional care) or being otherwise preventable with optimal ambulatory care.^{3, 12} The 3M algorithm includes AHRQ's ACSCs¹¹ as one of several categories of readmissions deemed to be potentially preventable.¹²

The objective of our study was to use the 3M classification of potentially preventable readmissions,¹² incorporating the CMS planned readmission algorithm,^{9, 10} to characterize 30-day readmissions that were and were not prevented by the MCCT. We systematically

examined the reasons for readmission among patients enrolled in MCCT and matched controls receiving standard post-discharge care, and identified differences in readmission reduction as a function of readmission type. Such an approach may reveal gaps in readmission prevention efforts, guide future program improvement, and identify patients at highest risk for readmission despite the resources of the MCCT.

METHODS

Study Design

This is a retrospective study comprised of two propensity-matched cohorts of elderly patients paneled to primary care providers (PCP) at Mayo Clinic Rochester, Minnesota, meeting criteria for MCCT enrollment, and discharged from a hospital between January 1, 2011 and June 30, 2013. The intervention group was enrolled in MCCT, while the matched control group received usual post-discharge care during the same time period. Patients were followed until hospital readmission, death, or 30 days after discharge, whichever came first. Mayo Clinic Institutional Review Board approved this study.

Study Population

Criteria for MCCT enrollment^{7, 8} and details of study participants⁸ have been previously described. Briefly, MCCT-eligible patients are ≥ 60 years old, live independently (e.g. not in a skilled nursing facility [SNF]) within the MCCT geographic catchment area, have established primary care with a Mayo Clinic PCP, and have an Elder Risk Assessment (ERA) score ≥ 16 at the time of hospital discharge. ERA is a validated risk stratification tool for identifying patients at high risk for hospitalization and emergency department use.^{13, 14}

Patients were identified as eligible for MCCT during index hospitalization by an automated electronic health record (EHR) algorithm that calculates the ERA and alerts MCCT staff. Patients were excluded from MCCT if they were discharged to hospice, were long-term SNF residents, or enrolled in a different care management program (dialysis or transplant). Patients who declined permission for research were excluded from all analyses in accordance with Minnesota law.¹⁵ Patients in the control group were eligible for MCCT enrollment but did not participate due to inadequate program capacity, established with to a non-participating PCP care team, and/or were missed for consideration of enrollment. Patients who refused MCCT enrollment despite eligibility were excluded from both groups.

Eligible MCCT and control patients were 1:1 propensity score matched^{16, 17} using patient age, sex, ERA score, index hospital length of stay, proximity of discharge date to January 1, 2011 (measure of program maturity), marital status, previous enrollment in other care coordination, intensive care unit stay, discharge to skilled nursing facility, presence of depression, and total number of chronic health conditions. Matched pairs were required to be within 0.2 propensity score standard errors. The effectiveness of propensity matching was based on comparisons of the standardized differences in the predictor variables between the cases and controls after matching was previously published.⁸

Intervention

Details of the program have been previously described.^{7, 8} Eligible patients were approached by the MCCT registered nurse (RN) during their index hospitalization to explain program details and offer enrollment. Enrolled patients were seen at their home by a nurse practitioner (NP) within 1–5 business days of hospital discharge for an intake evaluation, which included review of hospital course, medication reconciliation, chronic disease management plan, self-care education, review of resuscitation status, home setting assessment (including, but not limited to, mobility, safety, community resources, and caregiver support), and contingency planning for changes in clinical status. Patients remained in the program for 30 days, during which they received home visits from the NP and scheduled phone calls from the RN. RN triage phone line access was available for acute questions/needs and facilitation of acute home visits by the NP. The interdisciplinary team (RN, NP, internal medicine physician) met weekly to review enrolled patients.

Predictor Variables

EHR was used to extract patient demographics at the time of hospital discharge, as well as the principal diagnoses of index hospitalization, length of stay, discharge disposition, and comorbidities diagnosed over the preceding two years. Medications active on day of discharge were recorded. Comorbid conditions and hospital diagnoses were classified using the AHRQ Healthcare Cost and Utilization Project (HCUP) Clinical Classifications Software (CCS); see Table, Supplemental Digital Content 1, which provides CCS codes used to classify principal discharge diagnoses and chronic health conditions.¹⁸ Comorbidity burden was quantified using the weighted Charlson/Deyo comorbidity index.¹⁹

Primary Outcome

The primary outcome was the rate of 30-day potentially preventable vs. non-preventable hospital readmissions among patients enrolled in MCCT compared to matched controls.

First, we classified all index hospitalizations and 30-day readmissions using All Patients Refined Diagnosis Related Groups (APR DRGs). We then identified all planned readmissions using CMS criteria;^{9, 10} these were not subject to the 3M potentially preventable readmission algorithm. We applied the 3M Algorithm¹² to the remaining index hospitalizations (e.g. without a planned 30-day readmission). The 3M Algorithm first identifies hospitalizations that are ineligible to be index admissions or potentially preventable readmissions: certain metastatic malignancies, palliative or hospice care, select HIV diagnoses, and administration of chemotherapy or radiation therapy. Also excluded are admissions to non-acute care facilities, admissions to acute care for rehabilitation or convalescence only, hospitalizations among newborns (not applicable to this study), and index admissions where the patient left against medical advice. The remaining index admissions and 30-day readmissions are subject to the 3M Algorithm to determine if the readmissions are potentially preventable.

Potentially preventable readmissions were categorized into nine mutually exclusive categories: (1) medical readmission for continuation or recurrence of the reason for the index hospitalization, or for a closely related condition; (2) medical readmission for a

chronic problem that was not the reason for the index hospitalization, but may be related to care during or immediately after the index admission, excluding ACSCs; (3) medical readmission for an acute medical condition that may be related to or have resulted from care received during the index hospitalization or the post-discharge period; (4) surgical readmission to address continuation or recurrence of the problem that caused the index hospitalization; (5) surgical readmission to address a complication that developed as the result of the index hospitalization; (6) readmission for mental health reasons following index hospitalization for a reason other than mental health or substance abuse; (7) readmission for substance abuse reasons following index hospitalization for a reason other than mental health or substance abuse; (8) readmission for mental health or substance abuse reasons following index hospitalization for mental health or substance abuse; and (9) ACSCs as defined by AHRQ. Criteria for determination of potentially preventable readmission status and type are based on the 3M algorithm.¹² For the analyses, categories #4 and #5 (both surgical readmissions) were considered together.

Readmissions are deemed non-preventable for the following reasons: (1) readmission is not clinically related to index admission; (2) readmission is clinically related to the index admission, but is not preventable; (3) either the index admission or the readmission were for medical treatment for an immunocompromised state or metastatic malignancy; (4) either the index admission or the readmission were for medical treatment for multiple trauma; (5) transplant-related admissions. The 3M algorithm of non-preventable readmissions also includes obstetrics and planned readmissions, but these were not applicable to our study. Readmissions that were not eligible to be potentially preventable on the basis of the index hospitalization or readmission diagnosis (see above) were considered as non-potentially preventable.

Statistical Analysis

Baseline characteristics were compared between cohorts using t-tests, Wilcoxon ranksum tests, and chi square tests for continuous, ordinal and skewed continuous, and nominal variables, respectively. Fisher's exact test was used if there were fewer than 10 observations in a category. Readmission rates were assessed with Kaplan-Meier methods. Cumulative incidence rates of overall, potentially preventable, and non-potentially preventable readmissions were estimated with adjustment for the competing risks of death and readmission for other reasons (e.g., rates of preventable readmissions were adjusted for occurrence of non-preventable readmissions).¹³ Cox proportional hazards models were used to examine differences in cohorts for potentially preventable and non-preventable readmissions. Sensitivity analyses were performed using methods adjusted for the competing risks of death and readmission for other reasons, and the results did not change. Differences were considered statistically significant at $p < 0.05$. Analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

Study Participants

Details of the study population have been published previously.⁸ Briefly, 1587 patients met MCCT enrollment criteria between January 1, 2011 and June 30, 2013. Of these, 416 patients were excluded, 503 enrolled in the program, 57 opted out of the program, and 611 were eligible but were not enrolled and thus eligible to serve as controls. Patients were excluded if they were SNF residents (N=223), enrolled in hospice (N=62), enrolled in a dialysis care coordination program (N=10), enrolled in a transplant care coordination program (N=4), their PCP recommended against enrollment (N=16), lived outside the MCCT geographic catchment area (N=94), or for other miscellaneous reasons (N=7). Of the 503 patients enrolled in MCCT, 25 were excluded from matching because they refused research authorization (N=22) or lacked an ERA score (N=3). Of the 611 potential control patients, 74 were excluded due to lack of research authorization. The remaining patients, who were eligible to serve as controls, were not enrolled in the MCCT because they received primary care from a non-participating care team/site (N=226), desired palliative care (N=4), or for other specified reasons (N=47). The remaining 478 MCCT enrollees and 537 control patients underwent 1:1 propensity score matching and 365 pairs were successfully matched. The C-statistic for the propensity score model was 0.67.

Baseline characteristics of all eligible patients and the final matched cohorts are shown in Table 1. Prior to matching, MCCT enrollees were older than eligible controls, had more comorbidities, and had higher mean Charlson comorbidity index. After matching, MCCT and control patients were similar in age (83.1 vs. 83.3 years), gender (48.0% vs 49.3% male), race (95.9% vs. 97.3% white), and marital status (48.8% vs. 52.1% married). They also had comparable ERA scores and comorbidity burden, with similar rates of all examined comorbid conditions except for alcohol or substance use disorders, which were more prevalent among patients enrolled in MCCT than controls (10.4% vs. 4.9%; $p=0.005$).

Index hospitalization principal diagnoses and lengths of stay were comparable among MCCT enrollees and matched controls before and after matching (Table 2). The most prevalent diagnoses were gastrointestinal conditions, heart failure, pneumonia, sepsis, urinary tract infection, chronic obstructive pulmonary disease (COPD) or asthma exacerbation, complications of device or procedure, and myocardial infarction. MCCT enrolled patients were more likely to be hospitalized with a principal diagnosis of needing rehabilitation or adjustment of device/prosthesis (5.8%) compared to matched controls (2.7%); $p=0.04$. Use of opioids, sedative/hypnotics, insulin/sulfonylurea, cardiovascular medications (antihypertensive, diuretic, and anti-rhythmic medications), and warfarin and other anti-coagulants was similar between the two groups before and after matching.

Program Effect on Readmissions

Overall, patients enrolled in MCCT were significantly less likely to be readmitted than patients receiving usual care, with 45 total readmissions among MCCT enrollees (30-day readmission rate 12.4%; 95% CI, 8.9–15.7) and 72 among controls (30-day readmission rate 20.1%; 95% CI, 15.8–24.1); HR 0.58 (95% CI, 0.40–0.84), $p=0.004$ (Table 3). This

difference in readmissions was driven primarily by the decline in potentially preventable readmissions among MCCT enrollees (30-day readmission rate 8.4%; 95% CI, 5.5–11.3) compared to controls (30-day readmission rate 14.3%; 95% CI, 10.5–17.9); HR 0.56 (95% CI, 0.36–0.88), $p=0.01$ (Figure 1, Table 3). The 30-day rates of non-preventable readmissions were 4.3% (95% CI, 2.2–6.5) vs. 6.7% (95% CI, 4.0–9.4) among MCCT enrollees vs. controls, respectively; HR 0.63 (95% CI, 0.33–1.2), $p=0.16$. The number of planned readmissions was similar in the two groups.

A plurality of readmissions in both cohorts were for acute medical conditions or complications potentially related to the care received during the index admission or the post-discharge period (category #3): 43.3% of readmissions in the MCCT cohort and 40.0% in the control cohort. The next most common category of readmissions was continuation or recurrence of the reason for the index admission (category #1): 30.0% of readmissions in the MCCT cohort and 24.0% in the control cohort. Readmissions for ACSCs (category #7) were infrequent, particularly among patients enrolled in MCCT (2/365 vs. 6/365).

Although the study was not powered to detect small differences in readmissions within each category of potentially preventable readmissions, all categories of readmissions were lower in the MCCT cohort compared to controls (Table 3). The notable exception were readmissions for mental health (category #4) and substance abuse (category #5) diagnoses, which were rare overall but similar in frequency between the two groups.

CONCLUSIONS

Older community-dwelling, multi-morbid adults are at high risk for hospital readmission, and care transitions programs, including the MCCT, have been shown to reduce this risk.^{4, 5, 7, 8, 20} While traditionally post-discharge care has focused on the primary hospital diagnosis, we found that comprehensive home-based care and enhanced access to health care resources afforded by the MCCT nearly halved the rates of all potentially preventable readmissions among high risk community-dwelling elders. This includes readmissions for potentially unrelated conditions such as the ACSCs, though our study was underpowered for multiple subgroup analyses. The rates of non-potentially preventable readmissions were not significantly different, suggesting that not all unplanned hospitalizations may be avoided even with an intensive care transitions program. To our knowledge, this is the first study to specifically examine the effects of care transitions on preventable and non-preventable readmissions.

Two thirds of readmissions among MCCT enrollees and control patients were deemed potentially preventable. Such a high proportion is not inconsistent with previously published data when administrative data are used to define preventability, but there is marked variation in the proportion of readmissions deemed preventable depending on the definition of preventability used.^{21, 22} Most of the potentially preventable readmissions were related to the reason for the index hospitalization, either for an acute medical condition related to care received during the index hospitalization or post-discharge period, or for a continuation/recurrence of the reason for the index hospitalization. There were only two readmissions (7%) for ACSCs amongst the MCCT enrollees and six (12%) among the controls. The rarity

of ACSC readmissions is not surprising, as ACSCs were developed to identify deficiencies in primary and preventive care, not hospital or transitional care. This finding underscores the importance of looking beyond the ACSCs in the post-hospitalization period to identify potentially preventable hospitalizations, target interventions, and ultimately improve patient care and outcomes.

The reduction in readmissions deemed non-preventable with the MCCT was not statistically significant, though this may reflect a lack of power with small number of events in both groups. It is feasible that the MCCT can lower the rates of all readmissions, even those considered non-preventable, by delivering comprehensive and timely medical care, identification and correction of reversible risk factors, and completion of advanced care planning. We had not performed a post-hoc power calculation for this study because all available patients meeting study inclusion/exclusion criteria were included. However, given the low rate of non-potentially preventable readmissions in the control patients (4.7%), with 80% power of detecting a difference, the rate among MCCT patients would have had to be less than 1.2% to be statistically significant at $p=0.05$; the observed rate was 3.3%.

These findings reinforce the importance of intensive home-based transitional care for preventing all categories of potentially preventable readmissions irrespective of whether they are directly related to the index hospitalization and reason for MCCT enrollment. The MCCT encompasses multiple components of effective transitional care which have been shown to reduce hospital readmissions.²³ These operational components, which are also used for internal program evaluation and benchmarking, are consistent with the broad taxonomy of interventions proposed by Hansen and colleagues:²⁴ (1) medication reconciliation, which is part of the first MCCT home visit; (2) patient education; (3) timely follow-up, with the goal to see all patients at home within 5 business days of hospital discharge; (4) PCP communication; (5) availability of a patient hotline to triage acute concerns; and (6) home visits. Readmissions may therefore have been prevented by timely evaluation and management of the patients' acute health needs as soon as they arose,²⁵ as well as goals of care discussions,^{25, 26} medication reconciliation efforts, and facilitation of community health resources. We believe that the success of MCCT in preventing unrelated potentially preventable readmissions suggests that a similar approach may benefit all patients at high risk for hospitalization, not just the recently discharged, if delivered to at-risk individuals more broadly rather than limited to the context of hospital admission. Such programs would be aligned with ongoing efforts to reduce all hospitalizations, not just 30-day readmissions, particularly among patients with advanced or multiple comorbidities.

One limitation of this study is that the determination of potentially preventable readmissions was reliant on a computer algorithm applied to administrative data and not on full EHR review. Although some misclassification is possible, there is likely no bias in assessing preventability between the MCCT and matched control cohorts. Furthermore, the consistency of beneficial results across all categories of potentially preventable readmissions, and lack of impact on any non-potentially preventable readmissions, reinforces the validity of the 3M algorithm, which has been previously used and validated in other settings.^{3, 27-33} Another limitation is the generalizability of our findings, as the local population is predominantly white and the setting is small urban/rural. We also could not

assess the potential contributions of several known risk factors for hospital readmission in the geriatric population including advancing disease, falls, social determinants of health, 34–36 self-reported measures of health, and caregiver support.^{37, 38} Similarly, we could not identify post-discharge receipt of physical and/or occupational therapy, home health, and other resources that may have reduced readmission risk. One of the objectives of MCCT is to identify and facilitate patient referral to such services, and they may have been more prevalent in the MCCT cohort.

In summary, the MCCT is a successful care transitions program that reduces rates of all potentially preventable readmissions, including those unrelated to the reason for the index hospitalization. It can serve as a framework for innovative care delivery programs targeted at a variety of high risk patients, and particularly those who are homebound or face other barriers to timely access to care. Health care providers, health systems, and payers may therefore want to focus on a broader range of hospitalizations and readmissions, identify patients at highest risk and the specific events that may be avoided, and support innovative care delivery platforms to reduce these harmful but potentially preventable events.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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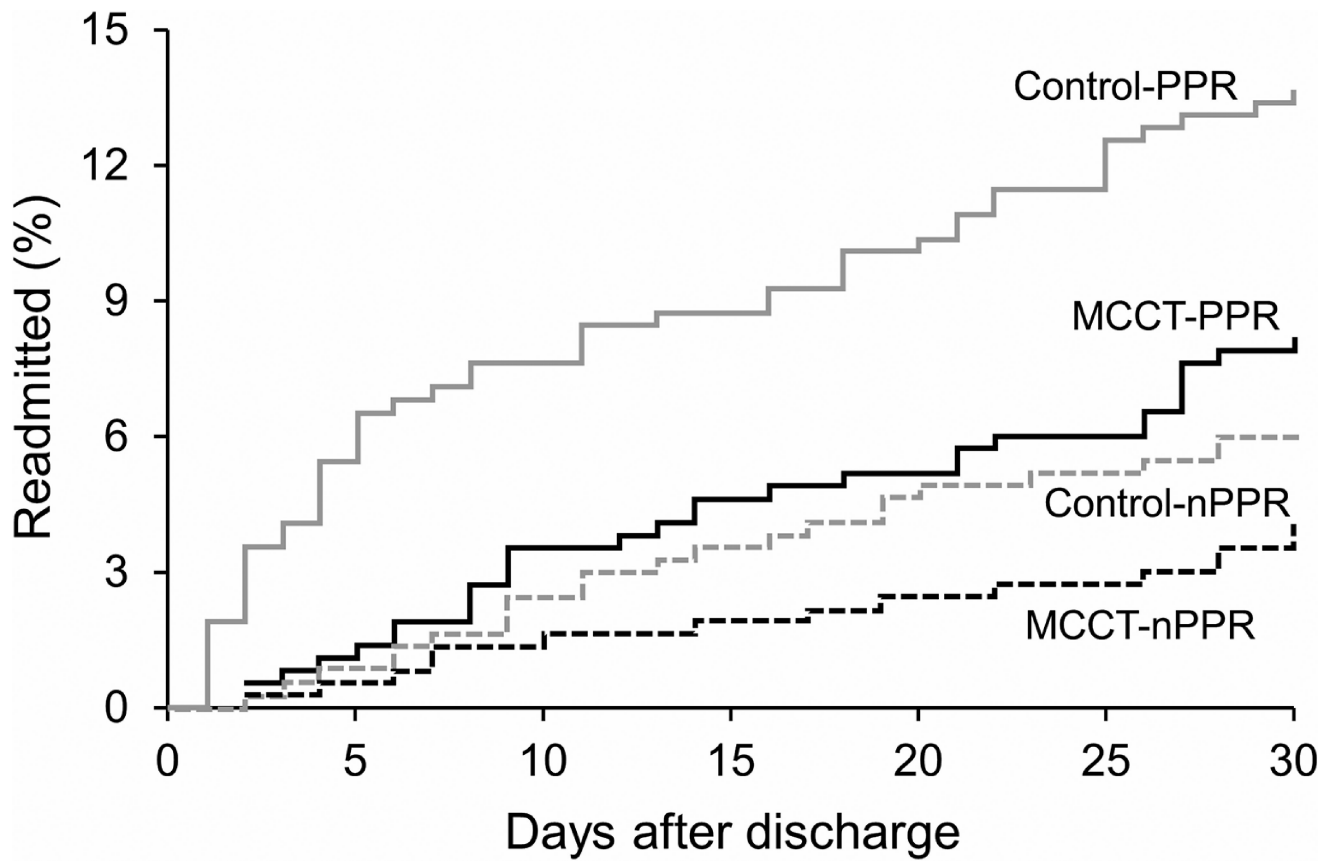


FIGURE 1. Effect of MCCT on potentially preventable and non-potentially preventable readmissions

For each curve, other readmissions were considered as competing risks. Patients without events were censored at 30 days.

TABLE 1

Baseline participant characteristics before and after propensity score matching.

	All MCCT (N=478)	Eligible Controls (N=537)	p-value	Matched MCCT (N=365)	Matched Controls (N=365)	p-value
Age, years, mean (SD)	83.6 (7.7)	82.4 (8.9)	0.02	83.1 (7.9)	83.3 (8.3)	0.81
Male, N (%)	238 (49.8%)	273 (50.8%)	0.74	175 (48%)	180 (49.3%)	0.71
White, N (%)	459 (96%)	515 (95.9%)	0.92	350 (95.9%)	355 (97.3%)	0.31
Married, N (%)	250 (52.3%)	251 (46.7%)	0.08	178 (48.8%)	190 (52.1%)	0.37
Comorbidities, N (%)						
Dementia	111 (23.2%)	104 (19.4%)	0.13	91 (24.9%)	69 (18.9%)	0.05
Heart failure	211 (44.1%)	195 (36.3%)	0.01	156 (42.7%)	139 (38.1%)	0.20
Coronary atherosclerosis	288 (60.3%)	302 (56.2%)	0.20	221 (60.6%)	224 (61.4%)	0.82
COPD/asthma	192 (40.2%)	232 (43.2%)	0.30	149 (40.8%)	163 (44.7%)	0.30
Stroke/TIA	123 (25.7%)	103 (19.2%)	0.01	90 (24.7%)	77 (21.1%)	0.25
Chronic kidney disease	165 (34.5%)	150 (27.9%)	0.02	119 (32.6%)	108 (29.6%)	0.38
Diabetes	219 (45.8%)	259 (48.2%)	0.44	159 (43.6%)	183 (50.1%)	0.08
Alcohol or substance use disorder	44 (9.2%)	34 (6.3%)	0.09	38 (10.4%)	18 (4.9%)	0.005
Arrhythmia	298 (62.3%)	290 (54%)	0.007	225 (61.6%)	208 (57%)	0.20
Hypertension	416 (87%)	453 (84.4%)	0.23	314 (86.0%)	316 (86.6%)	0.83
Cancer	190 (39.8%)	186 (34.6%)	0.09	142 (38.9%)	141 (38.6%)	0.94
Liver disease	72 (15.1%)	72 (13.4%)	0.45	51 (14%)	49 (13.4%)	0.83
Anxiety/depression	172 (36%)	184 (34.3%)	0.57	132 (36.2%)	135 (37%)	0.82
Other psychiatric condition	84 (17.6%)	82 (15.3%)	0.32	66 (18.1%)	57 (15.6%)	0.37
Other heart disease	262 (54.8%)	247 (46%)	0.005	192 (52.6%)	173 (47.4%)	0.16
Parkinson's disease	16 (3.4%)	13 (2.4%)	0.38	12 (3.3%)	8 (2.2%)	0.36
Osteoarthritis or rheumatoid arthritis	195 (40.8%)	194 (36.1%)	0.13	143 (39.2%)	136 (37.3%)	0.59
Osteoporosis	122 (25.5%)	110 (20.5%)	0.06	93 (25.5%)	81 (22.2%)	0.30
ERA score, mean (SD)	18.5 (3.2)	18.5 (2.6)	0.91	18.5 (3.1)	18.6 (2.7)	0.59
Charlson comorbidity index						
Mean (SD)	3.6 (2.4)	3.2 (2.3)	0.03	3.5 (2.4)	3.4 (2.4)	0.73
0	24 (5%)	39 (7.3%)		22 (6.0%)	27 (7.4%)	

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	All MCCT (N = 478)	Eligible Controls (N=537)	p-value	Matched MCCT (N=365)	Matched Controls (N=365)	p-value
1	73 (15.3%)	99 (18.4%)		49 (13.4%)	54 (14.8%)	
2	90 (18.8%)	101 (18.8%)		73 (20%)	66 (18.1%)	
3	76 (15.9%)	81 (15.1%)		61 (16.7%)	58 (15.9%)	
4	64 (13.4%)	76 (14.2%)		51 (14.0%)	54 (14.8%)	
5	58 (12.1%)	54 (10%)		45 (12.3%)	40 (11.0%)	
6	93 (19.5%)	87 (16.2%)		64 (17.5%)	66 (18.1%)	

NOTES: Marital status was patient-reported and classified as married vs. other (divorced, single, widowed).

Abbreviations: COPD, chronic obstructive pulmonary disease; TIA, transient ischemic attack.

TABLE 2

Index hospitalization characteristics before and after propensity score matching.

	All MCCT (N = 478)	Eligible Controls (N=537)	p-value	Matched MCCT (N=365)	Matched Controls (N=365)	p-value
Discharge diagnosis, N (%)						
Gastrointestinal conditions	40 (8.4%)	47 (8.8%)	0.83	30 (8.2%)	34 (9.3%)	0.60
Atrial Fibrillation and other cardiac dysrhythmias	23 (4.8%)	35 (6.5%)	0.24	16 (4.4%)	26 (7.1%)	0.11
Heart failure	44 (9.2%)	33 (6.2%)	0.07	30 (8.2%)	22 (6.0%)	0.25
Pneumonia	25 (5.2%)	35 (6.5%)	0.39	20 (5.5%)	22 (6.0%)	0.75
Myocardial infarction or coronary atherosclerosis	19 (4%)	29 (5.4%)	0.29	12 (3.3%)	21 (5.8%)	0.11
Rehabilitation, device/ prosthesis management	23 (4.8%)	15 (2.8%)	0.09	21 (5.8%)	10 (2.7%)	0.04
Sepsis	28 (5.9%)	23 (4.3%)	0.25	17 (4.7%)	13 (3.6%)	0.46
Urinary tract infection	18 (3.8%)	11 (2.1%)	0.10	16 (4.4%)	10 (2.7%)	0.23
COPD or asthma exacerbation	16 (3.4%)	32 (6.0%)	0.05	15 (4.1%)	25 (6.9%)	0.10
Acute renal failure	14 (2.9%)	22 (4.1%)	0.32	12 (3.3%)	15 (4.1%)	0.56
Arthritis/back issue	15 (3.1%)	29 (5.4%)	0.08	11 (3.0%)	13 (3.6%)	0.68
Cancer	17 (3.6%)	10 (1.9%)	0.09	16 (4.4%)	8 (2.2%)	0.10
Complications from device/procedure	18 (3.8%)	20 (3.7%)	0.97	12 (3.3%)	12 (3.3%)	1.00
Delirium or dementia	11 (2.3%)	13 (2.4%)	0.90	11 (3.0%)	8 (2.2%)	0.49
Hip fracture	11 (2.3%)	12 (2.2%)	0.94	8 (2.2%)	7 (1.9%)	0.79
Non-hip fracture	13 (2.7%)	23 (4.3%)	0.18	11 (3.0%)	11 (3.0%)	1.00
Adult respiratory failure	8 (1.7%)	5 (0.9%)	0.29	7 (1.9%)	4 (1.1%)	0.36
Syncope or dizziness	8 (1.7%)	4 (0.74%)	0.17	6 (1.6%)	4 (1.1%)	0.52
Skin Infection or ulcer	7 (1.5%)	6 (1.1%)	0.62	5 (1.4%)	4 (1.1%)	0.74
Hypertension	3 (0.6%)	5 (0.9%)	0.59	3 (0.8%)	5 (1.4%)	0.48
Stroke/TIA	12 (2.5%)	14 (2.6%)	0.92	9 (2.5%)	9 (2.5%)	1.00
Diabetes	3 (0.6%)	8 (1.5%)	0.19	1 (0.3%)	3 (0.8%)	0.62*
Alcohol or substance disorders	0	5 (0.9%)	0.06*	0	3 (0.8%)	0.25*
Psychiatric condition	0	5 (0.9%)	0.06*	0	3 (0.8%)	0.25*
Other	102 (21.3%)	96 (17.9%)	0.16	76 (20.8%)	73 (20.0%)	0.78
Length of stay, days, mean (SD)	5.5 (5.2)	5.4 (4.7)	0.66	5.4 (4.5)	5.2 (4.8)	0.67

Medication use, N (%)	All MCCT (N = 478)	Eligible Controls (N=537)	p-value	Matched MCCT (N=365)	Matched Controls (N=365)	p-value
Opioids	182 (38.1%)	184 (34.3%)	0.21	142 (38.9%)	126 (34.5%)	0.22
Sedatives/hypnotics	104 (21.8%)	124 (23.1%)	0.61	83 (22.7%)	90 (24.7%)	0.54
Cardiovascular drugs	446 (93.3%)	494 (92.0%)	0.43	335 (91.8%)	344 (94.3%)	0.19
Insulin or sulfonylureas	112 (23.4%)	123 (22.9%)	0.84	78 (21.4%)	89 (24.4%)	0.33
Warfarin or other anticoagulants	157 (32.9%)	147 (27.4%)	0.06	116 (31.8%)	101 (27.7%)	0.23

NOTES:

* Fisher's Exact test was used due to small sample size; all other comparisons were performed using the chi square test.

Abbreviations: COPD, chronic obstructive pulmonary disease; TIA, transient ischemic attack.

Total number and 30-day rates of readmission, by type of readmission. Shown are the absolute numbers (%) of patients with the 30-day outcome of interest and the 30-day readmission rates, which were calculated using Cox proportional hazards models taking into consideration the competing risks of other readmission categories.

TABLE 3

Type of readmission	MCCT (n = 365)		Controls (n = 365)		HR (95% CI) p-value
	N (%)	Readmission rate (95% CI)	N (%)	Readmission rate (95% CI)	
Readmitted (overall)	45 (12.3%)	12.4% (8.9, 15.7)	72 (19.7%)	20.1 (15.8, 24.1)	0.58 (0.40, 0.84) 0.004
Potentially preventable readmissions					
Medical readmission for a continuation or recurrence of the reason for the index admission, or for a closely related condition	9 (2.5%)		12 (3.3%)		
Readmissions for a chronic problem that may be related to care during or after the index admission	4 (1.1%)		8 (2.2%)		
Medical readmission for an acute medical condition or complication that may be related to care during the index admission or the post-discharge period	13 (3.6%)		20 (5.5%)		
Readmission for a mental health reason after a non-mental health index admission	2 (0.55%)		2 (0.6%)		
Readmission for a substance abuse reason after a non-substance abuse index admission	0 (0.0%)		1 (0.3%)		
Readmission for a surgical procedure to address continuation or recurrence of the problem at index admission; or that resulted from the index admission	0 (0.0%)		1 (0.3%)		
Readmission for an ambulatory care sensitive condition	2 (0.6%)		6 (1.6%)		
Readmission for mental health or substance abuse reasons following index admission for mental health or substance abuse	0 (0.0%)		0 (0.0%)		
Not potentially preventable readmissions^a					
Readmission may be clinically related, but was not preventable	12 (3.3%)	4.3% (2.2, 6.5)	17 (4.7%)	6.7 (4.0, 9.4)	0.63 (0.33, 1.2) 0.16
Readmission was not clinically related	1 (0.27%)		2 (0.55%)		
Index admission or readmission was for major metastatic malignancy ^b	4 (1.1%)		7 (1.9%)		
Index admission or readmission was for rehabilitation only ^c	4 (1.1%)		7 (1.9%)		
Planned readmissions^d					
Index admission or readmission was for rehabilitation only ^c	3 (0.82%)		1 (0.27%)		
	3 (0.82%)		5 (1.4%)		

NOTES:

^aReadmissions that were deemed not to be potentially preventable as well as those excluded from consideration of being potentially preventable are grouped together. The latter category includes index admissions and readmissions for major metastatic malignancy, rehabilitation, select HIV diagnoses, palliative or hospice care, obstetrics and newborn (not applicable to our study), transplant, and multiple

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trauma. Categories with no admissions/readmissions are not listed. Index admissions that resulted in patients leaving against medical advice are also excluded from analysis, but there were none in our study.

^b Major metastatic malignancy was the reason for non-preventable readmission in 5 index admissions in the MCCT cohort, 5 index admissions in the control cohort, and 2 readmissions in the control cohort.

^c Rehabilitation was the reason for non-preventable readmission in 3 readmissions in the MCCT cohort and 1 in the control cohort (none where the index stay was for rehabilitation).

^d Readmissions were first categorized as planned or unplanned according to the Center for Medicare and Medicaid Services (CMS) algorithm. Unplanned readmissions were then evaluated using 3M software to identify potentially preventable and not potentially preventable readmissions.