Evaluation of a multidisciplinary approach to reduce internal medicine readmissions using a readmission prediction index

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Purpose. Readmission prediction indices are used to stratify patients by the risk of hospital readmission. We describe the integration of a 30-day hospital readmission prediction index into the electronic medical record (EMR) and its impact on pharmacist interventions during transitions of care (TOC).

Methods. A retrospective cohort study was conducted to compare 30-day readmission rates between adult internal medicine inpatients admitted by a multidisciplinary team providing TOC services (the TOC group) and those who received usual care (the control group). Interventions by a pharmacist serving on the TOC team were guided by an EMR-integrated readmission index, with patients at the highest risk for readmission receiving targeted pharmacist interventions. Inpatient encounters (n = 374) during the 5-month study period were retrospectively identified. Chi-square and Mann-Whitney U tests were performed to analyze differences in nominal and nonparametric continuous variables, respectively. Logistic regression was performed to identify variables associated with 30-day readmissions. The log-rank test was used to analyze hazard ratios for readmission outcomes in the 2 cohorts.

Results. Thirty-day readmission rates did not differ significantly in the TOC group and the control group (20.9% vs 18.3%, P = 0.52). However, patients who received additional direct pharmacist interventions, as guided by use of a hospital readmission index, had a lower 30-day readmission rate than patients who did not (11.4% vs 21.7%, P = 0.04). The readmission index score was significantly associated with the likelihood of 30-day readmission (odds ratio for readmission, 1.25; 95% confidence interval, 1.16-1.34; P < 0.01). The difference in unadjusted log-rank scores at 30 days with and without pharmacist intervention was not significant (P = 0.05). A mean of 4.5 medication changes were identified per medication reconciliation performed by the TOC pharmacist.

Conclusion. A multidisciplinary TOC team approach did not reduce the 30-day readmission rate on an internal medicine service. However, patients who received additional direct pharmacist interventions guided by a readmission prediction index had a reduced readmission rate.

Keywords: clinical pharmacy service, medication reconciliation, patient readmission, readmission risk, transitions of care

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The Hospital Readmissions Reduction Program (HRRP), promulgated by the Centers for Medicare and Medicaid Services (CMS), incentivizes hospitals to reduce 30-day hospital readmissions by penalizing certain hospitals with excess readmissions of patients with certain disease states.[1,2] The program was developed in response to a landmark study demonstrating that almost 20% of Medicare patients were readmitted to a hospital within 30 days

following discharge, resulting in an estimated $17 billion in excess cost to the US healthcare system.[3] The HRRP has led to rapid growth in the number of published 30-day readmission risk indices, which are used to identify patients who may benefit most from transitions of care (TOC) interventions.[4,5] Despite a growing number of indices with moderate discriminatory capabilities, as assessed by receiver operating characteristic curve analysis,[5] there is a paucity of data linking these models to improved clinical outcomes.[6] Pharmacists represent one group of healthcare professionals that could potentially optimize patient outcomes through early identification of high-risk patients.[7,8]

Studies of the use of clinical pharmacists as purveyors of TOC interventions have demonstrated improved patient outcomes in the form of more accurate medication reconciliation,[9] reduced emergency department visits,[10] and reduced 30-day readmission rates.[11-15] However, these studies were heterogeneous with regard to multidisciplinary involvement and interventions employed, and many of the studies did not control for baseline variables that can impact 30-day readmission rates. Due to the lack of translational research on use of 30-day readmission indices to guide TOC interventions, we developed a multidisciplinary pilot project with collaboration between clinical pharmacists and an academic internal medicine physician group. The goal was to determine the influence of targeted pharmacist services on the likelihood of 30-day hospital readmission through the use of a readmission index and medical resident education.

KEY POINTS

- Clinical pharmacist–led medication reconciliation and patient education guided by a hospital readmission prediction index reduced 30-day readmissions and resulted in an average of more than 4 medication changes per patient.
- A multidisciplinary team approach to enhance transitions of care did not significantly decrease the 30-day hospital readmission rate relative to the rate with standard care.
- Readmission prediction indices, although useful in stratifying patients at high risk for readmission, should be subject to further study to determine their optimal role in clinical practice.

Methods

Study setting and readmission index. The study took place at Harper University Hospital of Detroit Medical Center, an academic university-affiliated hospital within an 8-hospital academic health system that serves a large uninsured and underserved population in southeastern Michigan. Study approval was obtained from the university's institutional review board. The Hospital All-Cause Thirty Day Readmission Index (HATRIX) was previously derived, validated, and integrated into the electronic medical record (EMR) of the health system, with a quarterly iterative validation process conducted to maintain model discrimination.[16,17] Briefly, the HATRIX is a 10-variable readmission index that stratifies patients by risk of 30-day all-cause readmission based on the following factors and conditions: previous hospital readmissions within the past 12 months, receipt of anxiolytic or antiarrhythmic medications, chronic kidney disease (including end-stage renal disease), essential hypertension, pulmonary heart disease, liver disease, anemia, congestive heart failure, and length of stay. The index is revalidated every 3 months to ensure that the odds ratios (ORs) for the model's variables are adapted to changes in the corresponding risk of readmission associated with the 10 variables.[16,17] The index is encoded in the health system's EMR, is updated on a daily basis, and is viewable by practitioners of all disciplines. A report that stratifies patients according to 30-day hospital readmission risk is generated each day. The top decile in each report represents the cohort with the highest risk of readmission.

Internal medicine model and pilot project development. The academic internal medicine program at the study institution consisted of 2 rotating hospitalist teams. Each team included an attending physician, 4 medical residents, and a variable number of medical students practicing within a 28-day rotation block. Teams alternated in admitting new internal medicine patients (ie, were "on call") at 48-hour intervals. In September 2017, a full-time clinical pharmacist specialist with a focus in TOC began rounding with the internal medicine teams. The pharmacist had 2 years of pharmacy residency training (postgraduate year 1 and pharmacotherapy residencies) and was board certified in pharmacotherapy (BCPS credential). The clinical responsibilities of the pharmacist specialist included attending multidisciplinary rounds Monday through Friday with the postcall internal medicine team; providing pharmaceutical care through the provision of medication reconciliation, education, and therapeutic drug monitoring; and answering drug information questions for all healthcare providers.

In January 2018, a TOC pilot intervention project was developed through collaboration between the departments of pharmacy and internal medicine. During each rotation block, 1 of the 2 teams was randomly assigned to be an experimental TOC team while the other provided standard-of-care services. All patients admitted by the experimental team (referred to hereafter as the TOC team) were eligible for additional TOC interventions by the clinical pharmacist. Patients had an equal chance of being admitted by either team. The average daily census for each team was 15, with a maximum of 20 patients per team. Patients admitted by the TOC team were selected for interventions based on their HATRIX score or at the discretion of the attending physician.

HATRIX scores were generated in a daily report for the TOC team, and patients with the highest scores were given priority for TOC interventions due to a higher likelihood of readmission. The additional TOC pharmacist interventions employed were admission medication reconciliation, discharge reconciliation, enrollment in a prescription discharge "medication to bed" program, education on medication and/or administration device technique, facilitation of prior authorization of medications if necessary, and postdischarge follow-up via telephone call within 7 days. Prior to the development of this protocol, all patients admitted to the internal medicine service were supposed to receive medication reconciliation by either nursing staff or medical residents, and discharge education was performed by each patient's nurse. Finally, during each rotation block medical residents on the TOC team were expected to attend three 20-minute lectures, respectively focusing on the importance of TOC, the HRRP, and an introduction to HATRIX scoring, delivered by the clinical pharmacist throughout the rotation. PowerPoint (Microsoft Corporation, Redmond, WA) lectures were developed by a clinical pharmacist and an attending physician champion. On the control team, a clinical pharmacist continued to provide medication therapy management for patients during multidisciplinary rounds and was available for drug information questions, but patients were not targeted for additional TOC interventions unless specifically requested by an attending physician or medical resident. The TOC specialist was not responsible for order verification outside of "pharmacy to dose" consults. For patients admitted by both teams who did not receive direct pharmacy intervention, admission and discharge reconciliation were completed by medical residents or nursing staff.

Study population and analysis. The project was a retrospective cohort study evaluating the difference in 30-day readmission rates for patients assigned to 2 internal medicine teams: the TOC team and a standard-of-care (control) team. All adult patients admitted to the academic internal medicine teams from January 28 through May 18, 2018, were eligible for inclusion. Patients were excluded if they left the hospital against medical advice, died during hospitalization, were transferred to another institution, or were discharged to a hospice, skilled nursing facility, or long-term care facility. For patients who were admitted more than once during the study period, only the first admission was included in the analysis. The primary outcome of the study was the difference in rates of 30-day all-cause hospital readmission between patients admitted by the TOC team and those admitted by the control team. Secondary outcomes included between-group differences in 15-day readmission rate, number and type(s) of pharmacist intervention(s), and time required for pharmacist intervention(s). Secondary analyses were performed to compare 30-day and 15-day readmission rates of patients who received additional direct pharmacist intervention and those who did not. Pharmacist interventions were defined as any type of medication reconciliation (admission, discharge, or postdischarge) performed for a patient.

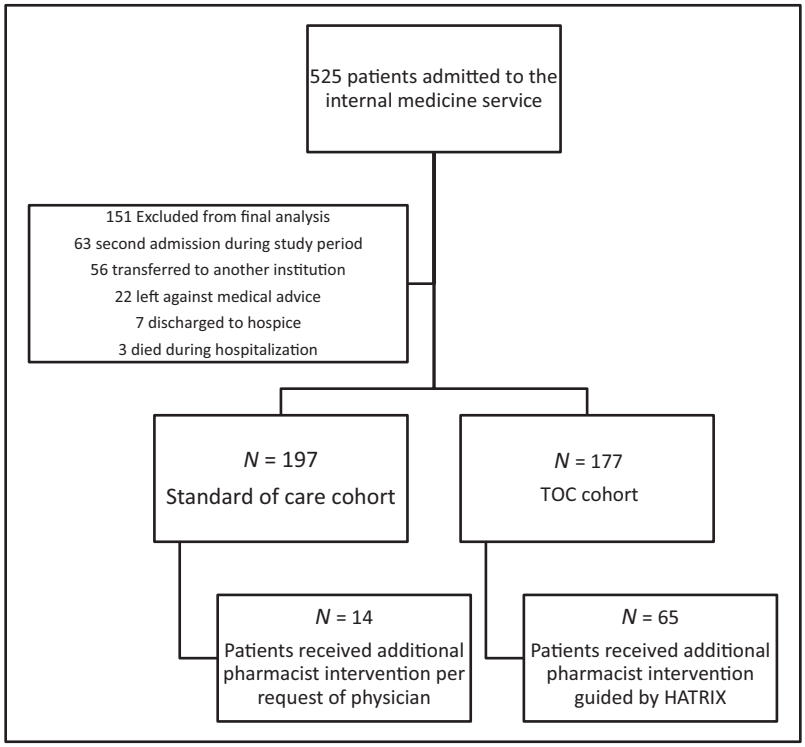
Statistical analysis was performed using SPSS version 24 software (IBM Corporation, Armonk, NY) supplemented with R statistical software, version 3.4.2 (Foundation for Statistical Computing, Vienna, Austria). A χ^2 or Fisher's exact test was used to assess differences in nominal variables, including baseline demographics and 30-day readmission rates, between groups. The Mann-Whitney *U* test was performed to assess for differences in ordinal or nonparametric continuous variables. Multivariable logistic regression was performed for statistically differing variables identified during analysis, and a log-rank test was used to analyze the hazard ratio for pharmacist intervention and 30-day readmission rates. An α value of <0.05 was considered statistically significant.

Results

Demographics. A total of 525 patients were admitted to the internal medicine service during the study period, of whom 374 were included in the final analysis (Figure 1). A full description of the demographic variables is presented in Table 1. There was no significant difference between the TOC and control groups with respect to age, gender, previous readmissions, 30-day readmission risk score, or intensive care unit admissions. Patients in the TOC group had a significantly longer median length of stay (3 days vs 2 days, $P < 0.01$) and a significantly higher proportion of patients with documented medication reconciliation interventions (36.7% vs 7.1%, $P < 0.01$). A total of 93 medication reconciliation events were documented for 79 patients. Specifically, 72 admission medication reconciliations, 11 discharge reconciliations, and 10 postdischarge reconciliations were performed by the clinical pharmacist during the study period. A mean of 4.5 changes to the medication list were made per patient who received medication reconciliation, with a mean of 22 minutes per patient spent performing medication reconciliation (Table 2).

Study outcomes. There was no significant difference in the 30-day readmission rate in the TOC group vs the control group (20.9% vs 18.3%, $P = 0.52$) during the intervention period (Table 1). There was also no significant difference in the 15-day readmission rate between the 2 groups (15.3% vs 13.2%, $P = 0.57$). However, when the patient cohort was analyzed by the presence or absence of additional pharmacist TOC interventions guided by HATRIX score (Table 3), there was a 48% reduction in the 30-day readmission rate in patients who received pharmacist intervention vs those who did not (11.4% vs 21.7%, $P = 0.04$). There was no significant difference in 15-day readmission rates in the TOC and control groups when analyzed by presence or absence of pharmacist intervention guided by HATRIX score (10.1% vs 15.3%, $P = 0.25$). Multivariate logistic regression was performed to

Figure 1. Flow diagram of patient sampling and cohort formation. HATRIX indicates Hospital All-Cause Thirty Day Readmission Index; TOC, transitions of care.



analyze 30-day readmissions in relation to the HATRIX score and pharmacist intervention variables. A HATRIX score in the top decile was associated with an increased risk of 30-day hospital readmission (OR, 1.25; 95% confidence interval [CI], 1.16-1.34; $P < 0.01$). Pharmacist intervention was associated with a 56% lower risk of 30-day readmission (OR, 0.442; 95% CI, 0.197-0.990; $P = 0.04$).

Readmission risk by group status and by intervention status was analyzed via Cox proportional hazards modeling (Figure 2). The difference in unadjusted log-rank scores for the TOC and control groups was nonsignificant ($P = 0.51$). The difference in log-rank scores also was not significant ($P = 0.05$) when comparing patients who received medication reconciliation interventions with those who did not.

Discussion

A team-based multidisciplinary TOC intervention did not significantly reduce the 30-day readmission rate relative to the rate with usual care. However, patients who received additional direct pharmacist intervention, as guided by a hospital readmission prediction index, had a lower 30-day readmission rate than those who did not. This finding adds to the growing literature demonstrating reduced readmission rates associated with pharmacist-led TOC programs within multidisciplinary teams. One academic medical center recently demonstrated a 52% relative reduction in 30-day hospital readmissions following initiation of the "Medication REACH" protocol, in which a pharmacist, nurse, and bridge coordinator provided medication reconciliation and education and followed up with patients after discharge.[12] Similarly, the IPITCH study, in which patients were randomly assigned to receive medication reconciliation, education, and postdischarge phone calls by a pharmacy specialist or to a standard-of-care group, found a significantly reduced rate of readmission and/or an ED visit in the intervention group vs the control group (24.8% vs 39.0%, $P = 0.01$).[14] In contrast to other studies, we performed a rigorous assessment of baseline variables already known to be associated with readmission through the inclusion of a 30-day readmission index that was previously derived and validated within our health system, which adds to the internal validity of the study.[16,17]

The association between reduced 30-day readmissions and direct pharmacist intervention is also noteworthy because it adds to the literature regarding potentially preventable readmissions. Studies analyzing the preventability of hospital readmissions have found that early readmissions (ie, admissions within 7 days of discharge) are more preventable than late readmissions (ie, those 8 to 30 days after discharge),[18] and there may be distinct differences in the patient populations readmitted at these time points.[19] Recent studies have also found that factors such as an ED physician's choice to admit, communication with outpatient providers, and discharging patients too soon are key variables in preventing readmissions, whereas medication-related factors are cited less frequently.[20,21] Although we did not analyze the specific reasons why pharmacist intervention may reduce readmissions, medication nonadherence,[22] poor patient communication,[20,23] and adverse drug events[24] have all been associated with hospital readmission. Our data demonstrate that additional pharmacist interventions reduced the 30-day readmission rate, but not the 15-day readmission rate, and that dedicated TOC pharmacists may represent a valuable resource for patients at risk for hospital readmission.

There are a number of potential reasons why readmission rates were not significantly different between groups despite the greater number of pharmacy interventions, which were independently associated with a reduced 30-day readmission rate. First,

Table 1. Demographics, Clinical Variables, and Outcomes by Study Group

Variable	Control Group (*n* = 197)	TOC Group (*n* = 77)	*P* Value
Age, median (IQR), y	54 (37-64)	42 (41-65)	0.82
Gender, No. (%) male	81 (41)	76 (43)	0.72
LOS, median (IQR), d	2 (2-4)	3 (2-5)	<0.01
HATRIX score, median % (IQR)	16.8 (9.6-32.1)	18 (12.3-30.9)	0.46
Prior hospitalizations, No. (%)			0.42
0	173 (87.8)	148 (83.6)	
1	16 (8.2)	21 (11.8)	
2	4 (2)	6 (3.4)	
≥3	4 (2)	2 (1.2)	
HATRIX variables, No. (%)			
Antiarrhythmic use	3 (1.5)	2 (1.1)	1
Anxiolytic use	49 (24.9)	51 (28.8)	0.39
Essential HTN	60 (30.5)	58 (32.8)	0.63
CKD	60 (30.5)	57 (32.2)	0.72
Hepatic impairment	13 (6.6)	13 (7.3)	0.84
Pulmonary heart disease	5 (2.5)	6 (3.4)	0.76
Anemia	66 (33.5)	60 (33.9)	0.94
CHF	41 (20.8)	45 (25.4)	0.29
ICU admission	38 (19.3)	40 (22.6)	0.43
Rx intervention(s), No. (%)[a]	14 (7.1)	65 (36.7)	<0.01
30-day readmission, No. (%)	36 (18.3)	37 (20.9)	0.52
15-day readmission, No. (%)	26 (13.2)	27 (15.3)	0.57

Abbreviations: CHF, congestive heart failure; CKD, chronic kidney disease; HATRIX, Hospital All-Cause Thirty Day Readmission Index; HTN, hypertension; IQR, interquartile range; LOS, length of stay; Rx, pharmacist; TOC, transitions of care.
[a]Medication reconciliation intervention documented in patient profile.

Table 2. Pharmacist Interventions During Study Period[a]

Variable	Value
Total no. of interventions (mean per patient)	354 (4.48)
Intervention type	
Dose changed, No. (%) of patients	68 (86)
Formulation changed, No. (%) of patients	21 (27)
Frequency changed, No. (%) of patients	11 (14)
Medication added, No. (mean per patient)	123 (1.56)
Medication deleted, No. (mean per patient)	131 (1.66)

[a]*n* = 79 patients (77 in intervention group and 2 in control group).

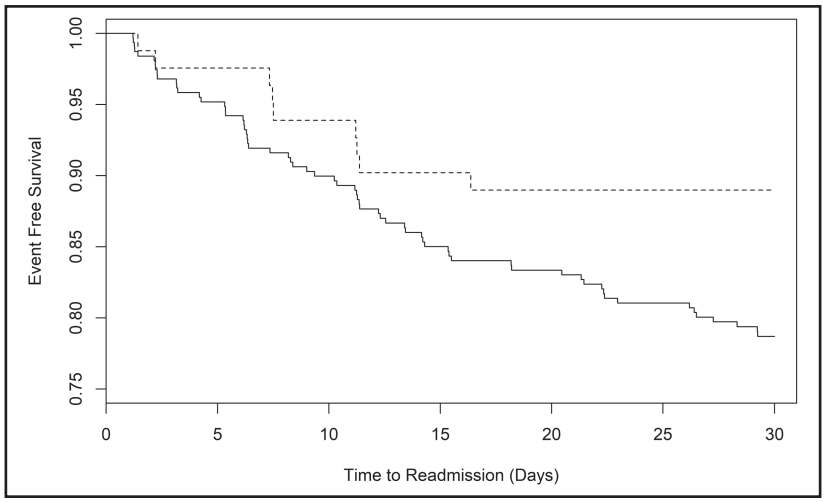
after the exclusion of patients with repeat admissions, a limited number of patients who received pharmacy intervention were included in the final analysis. The use of the readmission score to guide interventions led to the pharmacist targeting patients who are frequently admitted, as these patients carry the highest risk of subsequent hospital readmission. In HATRIX scoring, a history of 3 or more hospital admissions within 12 months is the variable associated with the highest OR for subsequent 30-day hospital readmission.[16] It is unknown whether patients with frequent readmissions or hospital-dependent patients benefit from pharmacy interventions, as those variables were not prespecified in our analysis.[25,26] Focusing TOC pharmacists away from frequently admitted patients would have led to more interventions for a greater number of individual patients, and this approach may be beneficial if medication reconciliation

Table 3 . Demographics and Outcomes Data Stratified by Pharmacist Intervention vs No Intervention

Variable	No Intervention (*n* = 295)	Intervention (*n* = 79)	*P* Value
Age, median (IQR), y	53 (38-65)	52 (41-66)	0.79
LOS, median (IQR), d	3 (2-5)	3 (2-4)	0.17
HATRIX score, median % (IQR)	17.5 (10.7-31.7)	17.9 (11.4-30.5)	0.99
Prior hospitalizations, No. (%)	120 (40.7)	37 (46.8)	0.33
0	254 (86.1)	67 (84.8)	0.79
1	27 (9.2)	10 (12.7)	
2	8 (2.7)	2 (2.5)	
3+	6 (2)	0	
HATRIX variables, No. (%)			
Antiarrhythmic use	4 (1.4)	1 (1.3)	1.0
Anxiolytic use	79 (26.8)	21 (26.6)	0.97
Essential HTN	94 (31.9)	24 (30.4)	0.80
CKD	91 (30.8)	26 (32.9)	0.73
Hepatic impairment	22 (7.5)	4 (5.1)	0.46
Pulmonary heart disease	7 (2.4)	4 (5.1)	0.21
Anemia	101 (34.2)	25 (31.6)	0.66
CHF	67 (22.7)	19 (24.1)	0.80
ICU admission	66 (22.4)	12 (15.2)	0.16
Outcomes			
30-day readmission	64 (21.7)	9 (11.4)	0.04
15-day readmission	45 (15.3)	8 (10.1)	0.25

Abbreviations: CHF, congestive heart failure; CKD, chronic kidney disease; HATRIX, Hospital All-Cause Thirty Day Readmission Index; HTN, hypertension; IQR, interquartile range; LOS, length of stay.

Figure 2. Results of Cox proportional hazards modeling of 30-day readmissions in patients targeted (dashed line) or not targeted (solid line) for pharmacist intervention. Event-free survival calculated as 1 – readmission rate.



programs are not deemed to have a strong impact in this population. Additionally, the same clinical pharmacist provided patient care during daily rounds for both the experimental and control groups. The emphasis on TOC may have resulted in statistical contamination, which would have biased the results towards the null; for example, patients cared for by the control team may have received other interventions outside of medication reconciliation, such as efforts to ensure their access to outpatient medications, that were not specifically analyzed in the study.

Another area of the study that requires further analysis is the use of a 30-day readmission index to guide pharmacy interventions. The use of the HATRIX tool to identify patients

for TOC interventions resulted in a reduced readmission rate; however, the mean HATRIX score was not significantly different between pharmacist-targeted patients and those who were not targeted, despite the fact that the index was specifically used to direct the pharmacist to patients with the highest scores. There are several possible explanations for this finding. First, the number of patients with high HATRIX scores might have varied on a daily basis. In addition, as part of the protocol, patients were also seen by a pharmacist at the specific request of the medical team, regardless of HATRIX score, even if there were other patients admitted with higher HATRIX scores. Second, the lack of a specific HATRIX cutoff value for determining which patients the pharmacist had to see might have led to self-direction by the clinical pharmacist. The pharmacist was guided by the daily report and chose patients who had the highest scores. Third, the exclusion of patients with repeat readmissions, as discussed above, may have decreased the mean HATRIX score of the pharmacist intervention group. Finally, the HATRIX model and similar models are unable to account for all possible reasons for readmission. Further studies may assist in identifying specific patient populations that benefit most from pharmacist intervention.

Our study had a number of limitations. As mentioned above, the same TOC pharmacist cared for patients of both the experimental and control groups simultaneously, which may have resulted in data contamination and biased the results towards the null. Although the majority of patients who received additional TOC-guided pharmacist interventions (n = 65) were assigned to the TOC team, 14 patients assigned to the standard-of-care team received such interventions per the request of the attending physician. In addition, although median HATRIX scores were used to control for baseline readmission risk, we were unable to control for additional factors not captured by the index, such as the effects of specific physicians, medical residents, or socioeconomic factors on 30-day readmissions. The majority of documented medication reconciliations were performed at admission; however, we did not analyze whether admission, transfer, or discharge medication reconciliation(s) had the greatest impact on the likelihood of future readmission. Finally, our study was retrospective, and the quality of the data and analysis were dependent on the accuracy of the data in the EMR. Despite these limitations, the study results add to a growing body of literature demonstrating the impact of clinical pharmacists during care transitions and suggest one method of incorporating 30-day readmission risk prediction models into clinical practice.

Conclusion

Development of a TOC pilot program and its use by an academic internal medicine team did not result in a 30-day readmission rate significantly lower than the rate among patients assigned to a standard-of-care team. However, patients who received additional direct pharmacist interventions guided by a 30-day hospital readmission prediction index had a lower 30-day readmission rate. Further studies are needed to clarify the role of 30-day readmission indices in clinical pharmacy practice.

Disclosures

The authors have declared no potential conflicts of interest.

Additional information

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