Capturing Outcomes of Clinical Activities Performed by a Rounding Pharmacist Practicing in a Team Environment

The COLLABORATE Study [NCT00351676]

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Background: Medical inpatients are at risk for suboptimal health outcomes from adverse drug events and under-use of evidence-based therapies. We sought to determine whether collaborative care including a team-based clinical pharmacist improves the quality of prescribed drug therapy and reduces hospital readmission.

Methods: Multicenter, quasi-randomized, controlled clinical trial. Consecutive patients admitted to 2 internal and 2 family medicine teams in 3 teaching hospitals between January 30, 2006 and February 2, 2007 were included. Team care patients received proactive clinical pharmacist services (medication history, patient-care round participation, resolution of drug-related issues, and discharge counseling). Usual care patients received traditional reactive clinical pharmacist services. The primary outcome was the overall quality score measured retrospectively by a blinded chart reviewer using 20 indicators targeting 5 conditions. Secondary outcomes included 3- and 6-month readmission.

Results: A total of 452 patients (220 team care, 231 usual care, mean age: 74 years, 46% male) met eligibility criteria. Team care patients were more likely than usual care patients to receive care specified by the indicators overall (56.4% vs. 45.3%; adjusted mean difference: 10.4%; 95% confidence interval [CI]: 4.9%, 15.7%) and for each targeted disease state except for heart failure. Team care patients experienced fewer readmissions at 3 months (36.2% vs. 45.5%; adjusted OR: 0.63; 95% CI: 0.42, 0.94) but not at 6 months (50.7% vs. 56.3%; adjusted OR; 0.78; 95% CI: 0.53, 1.15).

Conclusions: In patients admitted to internal and family medicine teams, team-based care including a clinical pharmacist, improved the overall quality of medication use and reduced rates of readmission.

Key Words: patient care team, pharmacists, internal medicine, family medicine, quality indicators

(*Med Care* 2009;47: 642–650)

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Supported by Capital Health Regional Pharmacy Services (to COLLABORATE). Ross Tsuyuki has received grants from Apotex, Astra Zeneca, Bayer, Bristol-Meyers Squibb, Merck Frosst, Pfizer, and Sanofi Aventis. He is supported by a University research chair in Patient Health Management funded by Merck Frosst.

Presented at**:** Canadian Society of Hospital Pharmacists Professional Practice Conference, Toronto, ON, Canada, February, 2008.

Dr. Makowsky had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis., Study concept and design: Makowsky, Koshman, Tsuyuki., Acquisition of data: Makowsky., Analysis and Interpretation: Makowsky, Koshman, Midodzi, Tsuyuki., Drafting of manuscript: Makowsky., Critical revision of manuscript for intellectual content: Makowsky, Koshman, Midodzi, Tsuyuki., Statistical analysis: Midodzi, Obtained funding: Tsuyuki., Administrative technical or material support: Makowsky., Study supervision: Makowsky, Tsuyuki.

This funding source was represented on the steering committee and together with other members provided feedback on study design, conduct, analysis, interpretation, and the final report. The sponsor was responsible for collection and storage of the pharmacist intervention data but had no role in the collection, storage, or analysis of the remaining data, was not involved in the preparation, review or approval the final manuscript and in the decision to submit the data for publication.

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ISSN: 0025-7079/09/4706-0642

Drug-related morbidity is largely preventable, and pharmacists represent a potential and currently underutilized resource for optimizing the use of medication in the hospital setting.[1–3] Although there are controversial reports that pharmacist care has little or a negative impact on patient outcomes;[4–10] several recent studies and systematic reviews have shown that pharmacists improve the quality of drug therapy,[11,12] process of care indicators, patient outcomes,[8,13–16] and quality of life,[17] and reduce the incidence of preventable adverse drug events,[1,2] mortality,[18,19] drug costs,[20] total costs of care,[20–22] length of stay,[20] medication errors,[23] and adverse drug reactions.[24,25] As such, a "core" set of clinical pharmacy services including medical rounds participation, admission drug histories, adverse drug reaction management, drug information, and drug protocol management have been defined by Bond et al who associated these activities with improved patient outcomes using data from 3 large American hospital databases.[19,26]

Healthcare teams including pharmacists have existed in the inpatient medical setting in medical centers for years.[27] Despite this, a recent survey of hospital pharmacy adminis-

trators across Canada suggests that several of these "core" services are not provided on a consistent basis.[3] This is the case in Capital Health institutions where due to a high patient load (eg, up to 60 patients/pharmacist) clinical pharmacists have been ward-based and have not typically been part of the core patient care team. Their role has been reactive, responding to prescription errors for patients whom the pharmacist has little direct clinical knowledge of and long after the decision to pursue a specific drug regimen has been made. Therefore, the objective of this study was to examine and validate a number of these "core" services in a Canadian population by determining the impact of provision of evidence-based services by a team-based pharmacist on process of care and patient outcomes, including predefined quality indicators and hospital readmission. This was compared with usual traditional, reactive, ward-based pharmacist services.

METHODS

Setting and Participants

The study occurred at 3 tertiary care teaching facilities in Edmonton, Alberta, Canada and involved 2 internal medicine clinical teaching unit (CTU) teams (University of Alberta Hospital and Grey Nuns Community Hospital) and 2 family medicine primary health care teams (PHCT) (Royal Alexandra Hospital and Grey Nuns Community Hospital). The internal medicine teams consisted of a senior medical resident, varying numbers of first year postgraduate residents and medical students who rotated monthly, supervised by a rotating staff internist who rotated weekly or every 2 weeks. The PHCTs were staffed by a general practitioner who rotated weekly and a nurse practitioner. Each team had a census of between 15 and 30 patients and admitted acutely ill medical patients, although PHCT patients are typically older and stay in hospital for longer periods of time. Prior to the study, proactive clinical pharmacy services were limited and pharmacists were not involved in medical rounds and rarely attended multidisciplinary team meetings.

Consecutive adults ($>$18 years of age) admitted to the participating teams between January 30, 2006 and February 2, 2007 were eligible for inclusion. For the purpose of outcome analysis, we included only patients with a most responsible or primary diagnosis of coronary artery disease (CAD), community acquired pneumonia (CAP), chronic obstructive pulmonary disease (COPD), heart failure (HF), or type 2 diabetes mellitus (T2DM). These disease states were chosen because they are among the most common reasons for admission to the participating teams, are associated with frequent hospital readmissions, and have high-quality evidence to support use of pharmacotherapy. Patients were identified after discharge via medical records using ICD-10 codes. For the outcome analysis, we excluded patients who were admitted for $\leq$2 days (due to inadequate time for pharmacist assessment and intervention), had a diagnosis of palliative cancer, were transferred to the care of another team/service, or resided outside the Capital Health catchment area.

Study Design and Procedures

We performed a multicenter, controlled clinical trial with blinded ascertainment of outcomes. We adapted and modified a 2 site "on-off" study design for 4 sites (ie, 4 teams).[28] This design was chosen to allow for the presence of a comparable control group. Two pharmacists were recruited and each was assigned to rotate between a CTU team and PHCT team. For 3 months at a time in sequential order patients admitted to the CTU team received team care ("On" period) while patients on the corresponding PHCT team received usual care ("Off" period). At the end of each 3 month block, the status was reversed, and the patients admitted to the PHCT team received team care while patients admitted under the CTU team received usual care. Since the intervention was team-based care, the unit of randomization was at the level of the team rather than the patient and the participating teams were randomized as to which would receive pharmacist team care first by flip of a coin. Allocation of patients to specific patient care teams occurred as per usual hospital procedures.

Intervention

The team-based pharmacists provided proactive clinical services, modeled on the philosophy of pharmaceutical care,[29] at the bedside as part of the medical team. When providing care these pharmacists: clarified and documented pharmacotherapy history, participated in bedside patient care rounds, identified and resolved actual and potential drug related problems, communicated patient-specific therapeutic recommendations to the team, and ensured that patients were discharged on appropriate drug therapy. As part of the admission, the pharmacist performed a thorough medication history and performed medication reconciliation. Medication reconciliation occurred again prior to patient discharge and the pharmacist reviewed changes to the medication regimen with the patient, and when deemed appropriate provided the patient a written summary and contacted the patient's community pharmacist or general practitioner. All drug therapy recommendations and monitoring plans were documented in the patient care record. Service was provided Monday through Friday during normal daytime hours to all patients admitted to the team.

Both team-based pharmacists had a Bachelor of Science in Pharmacy degree, had completed a 1-year hospital pharmacy residency and had practiced as hospital-based clinical pharmacists prior to participating in this study. One team-based pharmacist had 8 years of practice experience in an intensive care unit, whereas the other had a total of 5 years of experience in intensive care and internal medicine settings. A series of education sessions led by local pharmacist experts (1 on each target disease state and 1 on documentation of clinical care activities), was conducted with the team-based pharmacists prior to commencing the study.

Usual Care

Patients admitted during an "off" period received usual care. This included: reactive clinical pharmacy services provided by either ward-based or dispensary-based staff pharmacists. These pharmacists reacted to drug-related problems

identified in the dispensary or by pharmacy profile review, generally did not perform medication histories/reconciliation or attend patient care rounds, and only occasionally participated in patient education activities (usually at the request of a physician).

Outcomes and Measurements

Twenty quality indicators were defined to measure processes of patient care in response to gaps in translation of evidence-based therapies for the 5 identified disease states. The indicators were reviewed by local pharmacy and medicine specialists prior to the study. Valid reasons for nonuse of each intervention were also developed in order to exclude those patients who were not eligible for the intervention.

For each eligible patient, the quality indicators were evaluated retrospectively by a single, blinded chart reviewer (with a medical records background) after patient discharge. If quality indicator data were missing or not available in the chart, it was assumed that the indicator was not achieved. Where indicators were not met, the researcher assessed the notes section of the chart for explicitly documented evidence that would support the nonuse of the intervention. If necessary, a second investigator provided an independent assessment. Any disagreements were resolved by consensus.

Primary Outcome: Overall Quality Score

Similar to the article by Asch et al, the unit of analysis was adherence to a given indicator in a given patient.[30] For each patient, we determined the criteria that made participants eligible for the process specified in the indicator. We then determined whether the participant had received the specified process (Yes/No). For each patient, we determined an overall aggregate indicator score by dividing all instances in which participants received the recommended care by the total number of instances in which the care should have been received for the 5 specified most responsible or primary diagnoses. The score was constructed as a proportion ranging from 0% to 100% and where indicators for disease states overlapped (eg, use of DVT prophylaxis in a patient with HF and CAP) the indicator was only counted once. The primary outcome was an overall comparison of this outcome between team care and usual care groups.

Secondary Outcomes

Several secondary outcomes related to the quality indicators were assessed. We assessed achievement of quality indicators at the level of the disease state and individual indicator. Aggregate indicator scores (between 0% and 100%) were calculated at the level of the disease state (ie, CAD, CAP, COPD, HF, and type 2 diabetes mellitus) where only indicators for that disease state were used. When patients had multiple disease states and where indicators overlapped, the indicator was counted for each disease state. To account for patient's prior use of therapies relating to individual quality indicators (when applicable), we calculated the change in medication use from admission to discharge. When indicators were not achieved, we assessed instances where a reason for nonuse was explicitly documented.

Additionally, 3-month and 6-month all-cause hospital readmission (defined as any hospital admission or emergency department visit after the index hospital admission) was determined prospectively via linkage with the Capital Health regional admissions database. Finally, the number, type, acceptance rate, and expected clinical impact of pharmacist recommendations for the 2 team-based pharmacists was reported. This descriptive data were captured prospectively using the Regional Pharmacy Services Benchmarking form.

Statistical Analysis

A sample size of 650 patients was estimated for the study to have a statistical power of 80% to detect a 10% absolute increase in the mean overall quality score (ie, from

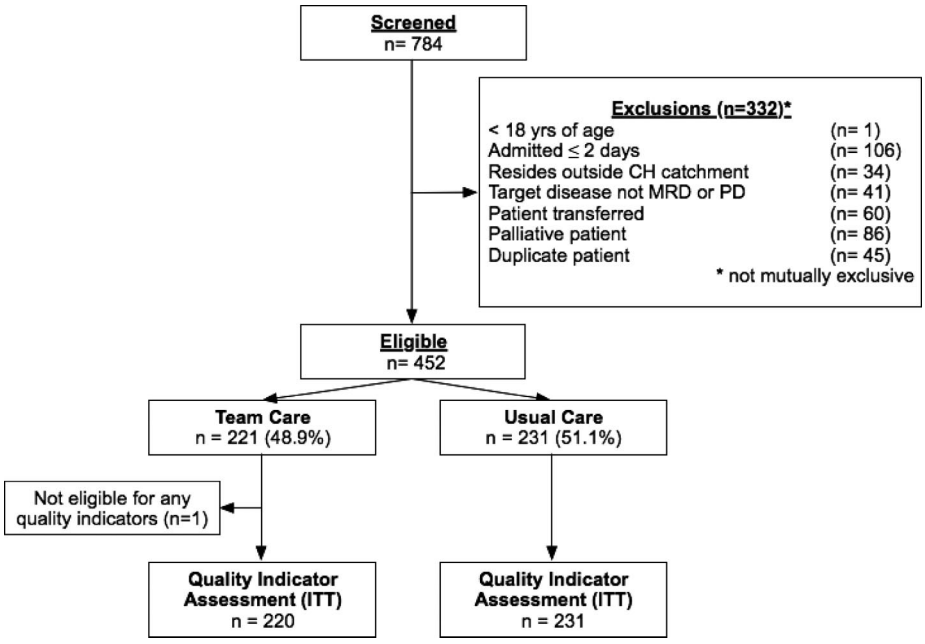

FIGURE 1. Enrollment and Allocation of Study Patients. CH indicates capital health; MRD, most responsible diagnosis; PD, primary diagnosis.

50% to 60%) with a standard deviation of 45% and a 2-sided alpha level of 0.05.

All results were analyzed at the Epidemiology Coordinating and Research Centre at the University of Alberta, using modified intention to treat principles, whereby patients were allocated to the team-based care group if they received at least 3 days of team-based care during the first 10 days of their hospital stay. Although the team was the unit of allocation, the patient was the unit of analysis and causal inference. This is justified by the anticipated small design effect, and the fact we expect that the outcomes for individual patients to be clinically and statistically independent of each other as each intervention is itself both patient and condition-specific. We calculated the impact of team care on readmission using the χ^2 statistic and odds ratios (OR) with the corresponding 95% CI. All tests of significance were 2 tailed and a P of 0.05 was considered to indicate statistical significance.

For each outcome, univariate analysis was used to asses the null effect and multivariate regression was used to control for the possibility of potential imbalances in patient-level characteristics. In our regression analyses, we included those variables deemed to be clinically important or those that differed statistically at a $P < 0.10$ between experimental arms. Further analysis was done to adjust for clustering of patients within site and by medical service.

To determine whether the results were sensitive to the impact of the potential carry-over effects introduced by the on-off design, an "on-treatment" analysis including only patients who were admitted and discharged entirely during a 3-month pharmacist service block was conducted. All analyses were conducted using SPSS, version 13.0 (SPSS Inc., Chicago, Illinois). The COLLABORATE study protocol was reviewed and approved by the Ethics Review Board of the University of Alberta. The requirement for patient consent was waived. This trial was registered at ClinicalTrials.gov, number NCT00351676.

RESULTS

Of the 452 patients eligible for inclusion; 221 (48.9%) received team care and 231 (51.1%) received usual care (Fig. 1). Overall, the mean age was 74.0 ± 14.3 years and 45.6% were men (Table 1). Over 50% of eligible patients had ≥2 target disease states as a most responsible or primary diagnosis (team care: 54.8% vs. usual care: 58.4%). The 5 most common diagnoses (or combinations of diagnoses) in the overall sample were: diabetes alone (15.3%), COPD alone (11.1%), CAP alone (8.8%), COPD and CAP (8.0%), and HF alone (7.1%). Baseline demographic and clinical characteristics were similar in the 2 groups, however, there were more internal medicine patients (particularly from UAH CTU-A) and fewer patients admitted with a most responsible or primary diagnosis of HF in the usual care group (Table 2).

TABLE 1. Baseline Characteristics

Sample Characteristic	Team Care n = 221	Usual Care n = 231
Age, yr (mean ± SD)	74.9 ± 13.9	73.2 ± 14.7
Male gender	104 (47.1)	102 (44.2)
Smoking history		
Current smoker	46 (20.8)	53 (22.9)
Former smoker	90 (40.7)	70 (30.3)
Never smoked	56 (25.3)	57 (24.7)
Most responsible or primary diagnosis		
Coronary artery disease	67 (30.3)	77 (33.3)
Community acquired pneumonia	69 (31.2)	77 (33.3)
Chronic obstructive pulmonary disease	98 (44.3)	94 (40.7)
Heart failure	81 (36.7)	62 (26.8)
Type 2 diabetes mellitus	91 (41.2)	101 (43.7)
Comorbidities, current (mean ± SD)	1.55 ± 1.54	1.63 ± 1.53
Comorbidities, history (mean ± SD)	5.39 ± 2.92	4.92 ± 2.64
Medications before admission		
None	21 (9.5)	23 (10)
Cardiovascular	124 (56.1)	124 (53.7)
Hypoglycemic	19 (8.6)	30 (13.0)
Respiratory	57 (25.8)	54 (23.4)
Service		
Internal medicine	142 (64.3)	160 (69.3)
Family medicine	79 (35.7)	71 (30.7)
Site		
UAH internal medicine CTU-A	61 (27.6)	79 (34.2)
RAH PHCT	34 (15.4)	35 (15.2)
GNCH internal medicine CTU-A	81 (36.7)	81 (35.1)
GNCH PHCT-orange	45 (20.4)	36 (15.6)

UAH indicates University of Alberta Hospital; RAH, Royal Alexandra Hospital; GNCH, Grey Nuns Community Hospital.

Pharmacist Recommendations

During the study period, the 2 team pharmacists logged a total 2653 patient contacts. The team pharmacists provided extensive clinical services and drug therapy recommendations (59.7 ± 23.3 recommendations/wk). The most common recommendations were to start new drug therapy (21.6 ± 11.8 recommendations/wk) change drug dosages (20.1 ± 8.5 recommendations/wk) or stop drug therapy (9.4 ± 5.4 recommendations/wk). The percentage of recommendations not accepted was 6.7% ± 6.0 recommendations/wk. The majority of recommendations were for drug efficacy maintenance (37.5 ± 16.0 recommendations/wk, to improve efficacy (20.8 ± 8.1 recommendations/wk), and reduce toxicity (12.6 ± 4.9 recommendations/wk).

Comparisons of Quality of Care

Tables 1 and 3 present the results of our analysis comparing quality of care between team care and usual care groups. Despite being admitted with a target disease state, 1 patient, assigned to team care, was not eligible for any quality indicators and therefore was excluded from analysis of this end point. Overall, team care patients were more likely than

TABLE 2. Adherence to Indicators Overall and by Disease Category

	Available Indicators (n)	Team Care			Usual Care			Mean Difference† % (95% CI)	Mean Difference‡ % (95% CI)	Mean Difference§ % (95% CI)
		Eligible Patients (n)	Events (n)*	Mean Score (%)	Eligible Patients (n)	Events (n)*	Mean Score (%)			
Overall	20	220	1102	56.4	231	1141	45.3	11.0 (5.6, 16.5)	10.2 (4.8, 15.6)	10.4 (5.0, 15.7)
CAD	4	67	250	65.4	77	287	50.1	15.3 (4.5, 26.1)	12.2 (1.3, 23.1)	11.4 (0.3, 22.5)
CAP	4	69	180	55.7	77	222	44.5	11.2 (3.1, 19.3)	12.5 (4.0, 20.9)	12.1 (3.5, 20.6)
COPD	6	98	468	54.7	80	477¶	43.2	11.5 (4.4, 18.7)	13.1 (7.0, 19.2)	12.2 (5.9, 18.4)
HF	4	81	283	44.1	62	231	41.8	2.3 (−7.0, 11.5)	−1.8 (−11.2, 7.6)	−1.3 (−10.8, 8.1)
T2DM	2	91	112	56.0	101	137	31.7	24.4 (11.6, 37.2)	19.5 (6.3, 32.7)	21.2 (8.0, 34.5)

*The number of events is the number of times indicators in the category were triggered.
†Unadjusted mean difference.
‡Mean difference adjusted for age, gender, intervention status, smoking, most responsible diagnosis, number of current conditions, number of prior conditions, and prior medication history.
§Mean difference adjusted for age, gender, intervention status, smoking, most responsible diagnosis, number of current conditions, number of prior conditions, prior medication history, and team characteristics (site and Internal or Family medicine services).
¶For all patients with COPD not only acute exacerbation.

patients receiving usual care to receive care specified by the indicators (56.4% vs. 45.3%; adjusted mean difference: 10.4; 95% CI: 4.9%, 15.7%). When analyzed by disease state, differences in quality scores between the 2 groups were statistically significant for all disease states except for HF (Table 3). In particular, the team care patients with CAD or type 2 diabetes were more likely to be discharged on antiplatelet therapy, team care patients with CAD were more likely to be discharged on statin therapy, and team care patients with COPD were more likely to receive influenza or pneumococcal vaccination (Table 1). Both groups showed similar change from previous use to discharge and this was not significantly different between team care and usual care groups.

Fifty patients (22.7%) in the team care group and 27 (11.7%) in the usual care group achieved a quality score of 100%. In cases where quality indicators were not achieved, a reason for nonuse was explicitly documented only in a minority of patients and this difference was not significant between groups (team care: 5.7% ± 21.2 vs. usual care: 2.6% ± 15.5; $P = 0.10$). The most common documented reasons for nonuse were a contraindication to therapy, deteriorating patient condition, and patient refusal.

Although efforts were made to maintain blinding of the chart reviewer, when asked to guess which group she thought the patient was allocated to, she was able to correctly identify pharmacist team care and usual care patients (sensitivity: 46%, specificity: 92%). The most common reason for unblinding was presence of a team pharmacist note in the patient chart.

All-Cause Readmissions

Patients assigned to team care experienced a lower rate of 3-month hospital readmission in both the crude and adjusted analysis (36.2% vs. 45.5%; adjusted OR: 0.63; 95% CI: 0.42–0.94) (Table 4). Six-month readmission, however, did not differ between groups (50.7% vs. 56.3%; adjusted OR: 0.78; 95% CI: 0.53–1.15).

Length of Stay

The median length of stay was increased in the team care group as compared with the usual care group in the adjusted analysis (adjusted median ratio: 1.16 [95% CI: 1.01, 1.34]) (Table 4).

On-Treatment Analysis

Confining the analysis to the 403 patients who were admitted and discharged entirely during team care or usual care did not change the direction or significance of the primary outcome; the adjusted overall quality score.

DISCUSSION

This multicenter, quasi-randomized, controlled trial demonstrated that the provision of team-based care including a pharmacist was effective in improving indicators of quality for the targeted disease states and 3-month hospital readmissions when compared with traditional reactive pharmacy services. Both the reduced number of admissions and improvement in medication use are clinically meaningful.

Better application of statin therapy, antiplatelet therapy, and increased rates of influenza and pneumococcal vaccination were most responsible for the differences seen between groups in the primary outcome. Although there were no differences in change in some individual indicators when prior use was taken into consideration, a study to evaluate these outcomes would require a much larger sample size; rather we powered this study to show improvement in overall quality of medication use. More rational medication use overall, combined with enhanced pharmacist involvement during the admission and discharge process and enhanced patient education may be responsible for the reduced readmission rate at 3 months.

Although the overall quality score was improved by team-based care, the CI around the estimates were wide and there are several potential explanations for the seemingly low rate of achievement of quality indicators in the team care group. First, is the weight that was given to prophylactic

TABLE 3. Comparison of Unadjusted Performance in Team Care Versus Usual Care Groups by Indicator

	Team Care (n = 220)			Usual Care (n = 231)				
Diagnosis/Indicators*, n for Eligible	**Previous Use†**	**Discharge‡**	***P***	**Previous Use†**	**Discharge‡**	***P***	***P*§**	**Breslow Day *P*¶**
CAD								
Discharge on statin[40]	39/67 (58.2)	45/67 (67.2)	<0.001	37/77 (48.1)	36/77 (46.8)	<0.001	0.014	0.251
Discharged on ACE inhibitor (n = 95 with T2DM or EF <40%)[40]	22/48 (45.8)	10/48 (20.8)	0.015	23/47 (48.9)	10/47 (21.3)	0.027	0.958	0.898
Discharge on antiplatelet[40]	38/67 (56.7)	48/67 (71.6)	0.009	37/77 (48.1)	41/77 (53.2)	<0.001	0.023	0.605
Discharge on beta blocker (n = 87 with history of MI)[40]	26/37 (70.3)	23/37 (62.2)	<0.001	25/50 (50.0)	26/50 (52.0)	<0.001	0.345	0.565
CAP								
Appropriate antibiotic regimen in first 24 h of admission[41]	—	64/69 (92.8)	—	—	72/77 (93.5)	—	0.857	—
DVT prophylaxis (n = 104 ONLY if MRD is CAP)[42–44‖]	—	19/48 (39.6)	—	—	16/56 (28.6)	—	0.236	—
Influenza vaccination (n = 23, >65-yr-old, admitted Oct-Feb, not vaccinated prior to admission)[41]	—	1/6 (16.7)	—	—	1/17 (5.9)	—	0.462	—
Pneumococcal vaccination (n = 56 >65-yr-old, not vaccinated past 5 yr)[45,46]	—	7/25 (28.0)	—	—	3/31 (9.7)	—	0.092	—
Acute exacerbation of COPD								
Short course steroid therapy [42,47]	—	60/89 (67.4)	—	—	50/80 (62.5)	—	0.503	—
Not discharged on new theophylline[47]	—	89/89 (100)	—	—	78/80 (97.5)	—	0.223	—
Antibiotics[42]	—	69/89 (77.5)	—	—	56/80 (70.0)	—	0.265	—
DVT prophylaxis (n = 169)[42–44‖]		35/89 (39.3)	—	—	28/80 (35.0)	—	0.561	—
Influenza vaccination (n = 60, admitted Oct-Feb, not vaccinated prior to admission)[41,47]	—	6/24 (25.0)	—	—	2/36 (5.6)	—	0.050	—
Pneumococcal vaccination (n = 128 not vaccinated past 5 yr) [45,47]	—	22/56 (39.3)	—	—	5/72 (6.9)	—	<0.001	—
HF								
ACE inhibitor/ARB (n = 113 EF <40%)[39]	40/61 (65.6)	43/61 (70.5)	0.001	28/52 (53.8)	28/52 (53.8)	<0.001	0.068	0.372
Warfarin for Afib (n = 68 with Afib)[39]	26/38 (68.4)	28/38 (73.7)	<0.001	18/30 (60%)	22/30 (73.3)	0.018	0.974	0.412
DVT prophylaxis (n = 80 ONLY if MRD is HF)[42–44‖]	—	13/44 (29.5)	—	—	16/36 (44.4)	—	0.163	—
Beta blocker in systolic HF (n = 113 EF <40%)[39]	28/61 (45.9)	38/61 (62.3)	<0.001	23/52 (44.2)	31/52 (59.6)	<0.001	0.771	0.294
T2DM								
Discharge on antiplatelet (n = 123, >40-yr-old)[48]	29/56 (51.8)	35/56 (62.5)	0.001	22/67 (32.8)	28/67 (41.8)	0.002	0.022	0.740
Influenza vaccination (n = 38, admitted Oct-Feb, not vaccinated prior to admission)[48]	0	0/12	—	0	0/26	—	—	—

*Indicators present in at least 1 eligible patient. Data are presented as: mean percent ± SD or n/N (%) as appropriate.
†Previous use: Refers to medications taken by the patients taken at home prior to admission.
‡On discharge or during hospital stay depending on indicator.
§*P* for team care at discharge vs. usual care at discharge.
¶Breslow Day *P* value evaluates difference in change score from previous use to discharge between team care and usual care groups.
‖At anytime during hospital stay.
ACE indicates angiotensin converting enzyme; ARB, angiotensin receptor blocker; Afib, atrial fibrillation; DVT, Deep vein thrombosis; DVT prophylaxis, unfractionated heparin or low molecular weight heparin; EF, ejection fraction; IV, intravenous; LVSD, left ventricular systolic dysfunction; MI, myocardial infarction; MRD, most responsible diagnosis.

medications in the quality indicator set. We documented poor application of prophylactic medications (ie, DVT prophylaxis, influenza, and Pneumococcal vaccination) in both team and usual care patients. Several other authors have documented poor application of DVT prophylaxis in medical patients and it is unclear if inaccuracy in medical records data may have lead to situations where this therapy was truly not indicated despite a diagnostic code indicating a particular diagnosis.[31–35] Second, is the decision to only evaluate indicators relating to use of evidence-based therapies for the 5

TABLE 4. Comparison of Team Versus Usual Care for Secondary Patient Outcome Variables

	Three Month Readmission	Six Month Readmission	Length of Stay (d)
Descriptive	n/N (%)		Median (Q25, Q75%)
Team care	80/221 (36.2)	112/221 (50.7)	9.0 (5.0, 18.5)
Usual care	105/231 (45.5)	130/231 (56.3)	8.0 (5.0, 14.0)
Univariate effect	Unadjusted odds ratios (95% CI)		Unadjusted median ratio (95% CI)
Team care	0.68 (0.47, 0.99)	0.80 (0.55, 1.16)	1.21 (1.04, 1.40)
Usual care	1.0	1.0	Reference
P	0.045	0.233	0.013
Multivariate effect*	Adjusted odds ratios (95% CI)		Adjusted median ratio (95% CI)†
Team care	0.65 (0.44, 0.96)	0.79 (0.54, 1.16)	1.18 (1.03, 1.36)
Usual care	1.0	1.0	Reference
P	0.029	0.224	0.018
Multivariate effect‡	Adjusted odds ratios (95% CI)		Adjusted median ratio (95% CI)†
Team care	0.63 (0.42, 0.94)	0.78 (0.53, 1.15)	1.16 (1.01, 1.34)
Usual care	1.0	1.0	Reference
P	0.024	0.217	0.031

*Multivariate analysis: adjusted for age, gender, intervention status, smoking, and most responsible, number of current conditions, number of prior conditions, and prior medication history.

†Length of stay was log transformed.

‡Multivariate analysis: adjusted for age, gender, intervention status, smoking, and most responsible, number of current conditions, number of prior conditions, prior medication history, and team characteristics (site and Internal or Family medicine services).

chosen disease states. For example, the indicator set was not sensitive to other important and commonly implemented pharmacist recommendations, such as adjusting medication doses for impaired renal function or discontinuing inappropriate drug therapies. Finally, a potential reluctance by the medical staff to deal with issues unrelated to the most responsible diagnoses during the acute hospital stay, especially if these issues were not "active," and a potential risk-treatment paradox manifested by a more conservative approach to patient care in the geriatric patient population included in this study were identified by the team-based pharmacists as issues during regular investigator meetings as the study progressed. This "risk-treatment paradox" has been clearly documented to exist in the geriatric population and may relate to questions about applicability of clinical practice guidelines in elderly patients.[36–38]

The finding of no difference in readmission at 6 months despite a decrease at 3 months in our intent-to-treat population may be explained by a potential clustering of preventable readmissions occurring early (ie, within 1 month) to discharge,[39] a "wearing off" of the pharmacists intervention due to disease progression, changes in medications, or an inadequate dose of the pharmacist intervention.

A series of landmark articles published by Bond et al have documented that among Medicare recipients in the United States, the presence of clinical pharmacy services were associated with reduced mortality, drug costs, total costs of care, length of stay, medication errors, and adverse drug reactions.[18–21,23,24] Additionally, a recent systematic review by Kaboli et al concluded that the addition of clinical pharmacist services in the care of hospital inpatients generally resulted in improved care with no evidence of harm.[25] They documented that medication adherence, knowledge, and appropriateness improved in 7 of 11 studies, hospital stay was shortened in 9 of 17 studies and adverse drug events, adverse drug reactions, and medication errors were reduced in 7 of 12 trials that included these outcomes. No intervention led to worse clinical outcomes and only 1 reported higher health care use.[25]

Our results add to the literature by providing further evidence to support the role of clinical pharmacists improving the appropriateness of medication use in the hospital setting. Our study is one of few to show a statistically significant impact of pharmacist intervention on hospital readmission. This outcome was positive in only 1 of 12 studies looking at this outcome in the Kaboli et al review and Bond et al have not studied this outcome. Although we documented an increased length of stay among patients assigned to receive the pharmacist intervention, unknown characteristics may have influenced this outcome, or it is possible that the desire to monitor medication changes suggested by the team-based pharmacists in this study may have led to delays in patient discharge.

The strengths of this study include its pragmatic design, involvement of multiple centers, a clearly defined intervention, relatively large sample size, and standardized collection of data by a single chart reviewer. However, there are some limitations that warrant discussion. First, although the overall quality score has high face validity, we are the first to use this specific combination of outcomes and have not performed formal assessment of its validity. Second, as the quality indicators were determined by retrospective chart review, we were only able to assess eligibility and achievement of the indicators based on information contained in the patient chart. This methodology, however, was felt to be the best option as other alternatives, including prospective evaluation in the intervention group and retrospective evaluation in the usual care group would introduce bias during data collection, and prospective data collection in both groups was not feasible

due to ethical concerns in withholding potential interventions identified by pharmacist from usual care patients. Third, although all efforts were made to maintain blinding of the chart reviewer, we were not always successful in maintaining this. Nevertheless, the outcome measures evaluated by the chart reviewer were objective (ie, drug use). Fourth, our study was not truly a randomized controlled trial. However, due to the nature of the intervention, randomization at the level of the patient was felt to be impossible. Fifth, although the team-based pharmacists in our study had residency training and several years of work experience, we feel that the intervention provided is generalizable and could be provided by the majority of pharmacists when attention is given to providing mentorship and education support. Finally, our original sample size estimation was 650 patients; however, due to funding constraints the study period was limited to 1 year. Nevertheless, we demonstrated significant beneficial effects on quality of medication use and hospital readmission.

CONCLUSION

In conclusion, we found that integrating a pharmacist on the medical team to perform and document a medication history, attend patient care rounds, identify and resolve drug related issues, and provide discharge medication counseling, improved the quality of medication use, and reduced 3-month readmission rates for patients admitted to internal and family medicine teams with a diagnosis of coronary artery disease, CAP, chronic obstructive pulmonary disease, HF, and type 2 diabetes. This trial suggests that the traditional ward-based pharmacist paradigm should be changed to that of team-based pharmacist care in medicine settings.

ACKNOWLEDGMENTS

The authors thank Lisa Tate and Dayle Struhan (study pharmacists), Dr. Bill Coke, Dr. Ed Holmes, Dr. Greg Hrynchyshyn, and Dr. Irene Colliton on behalf of members of the participating Medicine and Family Medicine teams, as well as Carolyn Nilsson (chart review), Dr. Sumit Majumdar and Dr. Jeff Johnson (methods development). Additionally, the authors wish to thank Dr. Scot Simpson, Dr. Deon Druteika, Margaret Gray, and Lindsay Torok-Both (pharmacist training update), Theresa Schindel (PHARMALearn web-based educational module access), Brian Humeniuk and Chris Houston (clinical information analysis), members of the COLLABORATE steering committee and the Epidemiology Coordinating and Research Centre/COMPRIS staff for their involvement.

COLLABORATE Steering Committee:

Gail Hufty, Mark Snaterse, Dr. Tania Mysak, Dr. Margaret Ackman, Dr. Deon Druteika, Jeff Whissell, Lorraine Delano, Lindsay Torok-Both, Dr. Michelle Foisy, and Margaret Gray all with Regional Pharmacy Services, Capital Health.

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