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Title Page

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This study was conducted with funding from the Department of Health and Human Services, Victoria, Australia. There are no conflicts of interest to declare.

Multi-site Evaluation of Partnered Pharmacist Medication Charting and in-hospital Length of Stay

Structured Abstract:

Objectives - To undertake a multi-centre evaluation of translation of a partnered pharmacist medication charting (PPMC) model in patients admitted to General Medical Units in public hospitals in the state of Victoria, Australia.

Design - Unblinded, prospective cohort study comparing patients before and after the intervention

Setting –Seven public hospitals in Victoria, Australia from 20 Jun 2016 to 30 June 2017.

Participants – Patients admitted to General Medical Units.

Interventions – Medication charting by pharmacists using a partnered pharmacist model compared to traditional medication charting.

Main outcome measures - The primary outcome variable was the length of inpatient hospital stay. Secondary outcome measures were medication errors detected within 24 hours of the patients' admission, identified by an independent pharmacist assessor.

Results – A total of 8,648 patients were included in the study. Patients who had PPMC had reduced median length of inpatient hospital stay from 4.7 (IQR 2.8-8.2) days to 4.2 (IQR 2.3-7.5) days ($p<0.001$). PPMC was associated with a reduction in the proportion of patients with at least one medication error from 66% to 3.6% with a NNT to prevent one error of 1.6 (95% CI: 1.57-1.64).

Conclusions - Expansion of the partnered pharmacist charting model across multiple organisations was effective and feasible and is recommended for adoption by health services.

Trial registration - Australian New Zealand Clinical Trials Registry (ACTRN12616000961448)

What is already known:

Medication errors are among the most common incidents reported in hospitals and often occur at hospital admission. Strategies to reduce harm include use of information technology, clear medication labeling and medication reconciliation, which have been used with varying success.

What this study adds:

This is the largest study of its kind conducted across multiple hospitals, demonstrating reduction in length of hospital stay and medication errors from a collaborative medication-charting model involving a doctor and a pharmacist. Expansion of a collaborative medication-charting model to reduce length of hospital stay and medication errors can have a large impact in an era where physician burnout is a major concern, balanced against reducing clinical risk for patients and maximising the use of resources available.

Introduction

Medication errors are among the most common incidents reported in hospitals and commonly occur at hospital admission.[1,2] Patients at significant risk include those who are admitted to hospital General Medical Units (GMU) as they are often complex with multiple comorbidities receiving multiple medications, and at risk for medication-related problems associated with increased morbidity and mortality.[3-5] Major factors in the cause of medication prescribing errors include work factors (e.g. environment, workload), medication factors (e.g. similar sounding names, low therapeutic index), and patient factors. Strategies to reduce harm include use of information technology, clear medication labeling and medication reconciliation, which have been used with varying success. [6,7]

Medication reconciliation and review of patients' medications by pharmacists, however, is not routine in most settings and if it occurs, it is often some time after admission. Subsequently, errors relating to medications are often not identified or rectified in a timely manner and result in patient harm and increased duration of hospitalisation. [8]

A pilot study conducted in 2012 demonstrated feasibility of a multidisciplinary approach to improve timely care and reduce medication errors by introducing an early collaborative review by a medical officer and pharmacist as soon as possible after the patient admission, followed by the charting by pharmacists of medication for administration.[9] A single centre randomised controlled trial, conducted in 2016, confirmed a significant reduction in medication error rates with the implementation of this partnered pharmacist medication charting (PPMC) model when compared to standard medical charting.[10] The aim of this study was to translate the above evidence and undertake a multi-centre evaluation of the effectiveness of the PPMC model in patients admitted to GMUs in seven public hospitals in the state of Victoria, Australia.

Methods

The evaluation took place in general medical units in seven public hospitals in Victoria and was funded by the Department of Health and Human Services, Victoria, Australia. Patients were included from the following hospitals: *(removed names of hospitals for deidentification purposes)*. Public hospitals in Australia are primarily government funded. Of the included sites, one site had electronic prescribing in place for the duration of the study.

Trial Design and oversight: This unblinded, prospective cohort study compared cohorts of patients before and after the intervention. The study was approved by *(removed for deidentification purposes)* Hospital Research and Ethics Committee with reciprocal approval from all sites (Approval number 161/16) and registered on the Australian New Zealand Clinical Trials Registry (ACTRN12616000961448).

Patient and Public Involvement: Patients and the public were not directly involved in the design of this study, but committees that include patient representatives reviewed the PPMC model and the study design.

Participants: The pre-intervention cohort included patients who had their medication chart written in the period 20th June 2016 to 24th September 2016. All institutions during this period followed the traditional model of medication charting where a medical officer charted medications including venous thromboembolism (VTE) prophylaxis after the admission process with subsequent medication reconciliation performed by a pharmacist within 24 hours of admission.

The post intervention cohort included patients who had their medication chart written in the period which followed the introduction of the PPMC model in the period 25th September 2016 to 30th June 2017.

Intervention: The PPMC model involves a pharmacist taking a medication history, performing a VTE risk assessment, and then having a face-to-face discussion with the admitting medical officer about current medical and medication related problems, following which a medication management plan is agreed upon. The VTE risk assessment involves assessing a patient's risk of venous thromboembolism as an inpatient and determining whether thromboprophylaxis is required. The medication management plan includes which medications are to be charted for the patient, and which medications are to be ceased, withheld or modified. It may also include relevant investigations that are to be undertaken that relate to the patient's medications. Appropriate pre-admission medications and VTE prophylaxis were then charted by the pharmacist on the inpatient medication record from which nurses administer medications. This was followed by a discussion between the treating nurse and pharmacist about the medication management plan, including any urgent medications to be administered, medication-related monitoring and reasons for any changes to medications. A second pharmacist, as an independent assessor, reviewed all medications charted by a pharmacist within 24 hours, to provide a second check and identify any medication errors. [9]

The same PPMC model was implemented at each site, including requirements for a unit-based clinical pharmacy service to the GMU, a minimum ratio of 1 pharmacist to 20 general medical inpatients, a structured credentialing program provided by the lead site for pharmacists and a standard procedure for the implementation and delivery of the PPMC model approved by hospital governance at each site.

All pharmacists undertaking partnered pharmacist charting undertook a structured credentialing program that included a case-based objective structured clinical examination (OSCE) with a general physician and senior pharmacist. As part of the implementation of the PPMC model across seven new sites, the lead site was responsible for credentialing both a medical consultant and senior pharmacist to perform the credentialing process including the OSCE for pharmacists at their own sites.

Outcomes: The primary outcome variable was the length of inpatient hospital stay (LOS). Secondary outcome measures were patients with medication errors detected within 24 hours of admission, identified by an independent pharmacist assessor. The assessor was not blinded to whether the admission chart was written by a pharmacist or medical officer and was not part of the patient's admission process. Errors identified were classified as omitted medication, incorrect dose/frequency, incorrect/unnecessary medication or incorrect route

of prescription. If an error was identified, standard care occurred and the pharmacist notified the treating team of the error.

Due to the large volume of errors identified and a previous randomised controlled trial demonstrating a reduction in high and extreme risk errors,[10] a subset of one in ten errors in the pre-intervention phase were randomly selected and assigned a risk rating by a blinded independent expert panel. The panel comprised a general physician, an emergency physician and a senior clinical pharmacist. All errors identified in the intervention phase were reviewed. The panel used a previously validated consequence/probability matrix to review the errors. [11] The matrix required the panel to agree on the most plausible natural consequence that could occur to the patient on the hypothetical assumption that no specific intervention was made to rectify the medication until 48 hours after admission, and then to adjudicate on the severity of such a consequence and the likelihood of its occurrence. Errors were classified as on an ordinal severity scale of 1-5 (insignificant, low risk, moderate risk, high risk or extreme risk) using the aforementioned consequence/probability matrix. Other secondary outcome measures were proportions of types of errors and proportions of extreme or high-risk errors. The same methodology was used to identify errors in the pre-intervention and intervention phases of the study.

Statistical analysis: Normally distributed continuous data are presented using means (standard deviation) while ordinal and skewed data are presented using medians (inter-quartile range (IQR)). Statistical significance was defined by a p-value of <0.05. Differences in the secondary outcome were presented using relative risk of an error and the number needed to treat (NNT) to prevent one error. A per-protocol analysis was performed comparing patients in the pre-intervention cohort to patients that received the intervention in the post-intervention cohort. Statistical significance of difference in means was evaluated using the Student's t-test and difference in medians were evaluated using the Wilcoxon Rank-Sum test. The association between PPMC and l inpatient LOS was further assessed by adjusting for potential confounders listed in Table 1 using multiple linear regression analysis. All analyses were conducted using Stata v 11.0 (College Station, Texas).

A clinically important reduction in length of inpatient hospital stay was defined as a 5% reduction from the baseline. Assuming the length of inpatient hospital stay in the pre-intervention cohort to be 5.0 (SD 3.0) days and using a power of 90% and a two-sided significance (alpha) level of 0.05, the total sample size required was 6,054, with 3,027 in each arm.

Results

In the pre-intervention phase, 5,612 patients were admitted to the seven general medical units and received standard medical officer medication charting and medication reconciliation by a pharmacist. A total of 27,924 patients were admitted to the seven general medical units during the intervention period. Of these, 3,036 received PPMC; these patients comprised the intervention cohort. Patient demographics and clinical characteristics, including age, number of medications, triage category at presentation and Charlson comorbidity index, are detailed in Table 1. The total number of medications charted was 53,371 in the pre-intervention (medical charting) cohort and 31,658 in the intervention (PPMC) cohort.

The median (IQR) length of inpatient hospital stay was 4.7 days (2.8-8.2) in the pre-intervention phase and 4.2 days (2.3-7.5) among patients that received PPMC (p<0.001) (see table 2). Of the 5612 patients who received standard medical charting during the pre-intervention period, 3701 (66%) had at least one medication error identified compared to 111 patients (3.6%) using PPMC (p<0.001).

A total of 1,020 errors from the 10,233 errors identified in the pre-intervention phase were evaluated for severity, with 271 errors (27%) stratified as high or extreme risk (table 3). All errors in the intervention phase (130) were also evaluated by the expert panel with 27 errors (21%) stratified as high risk. There were no extreme risk errors identified among patients undergoing PPMC in the intervention phase.

Of the 27 high-risk errors identified in the intervention phase, 16 (59%) involved cardiovascular medications, 2 (7.5%) involved analgesic medications and 2 (7.5%) involved anticoagulants.

The relative risk of a patient having at least one error with partnered pharmacist charting was 0.11 (95% CI: 0.09-0.13) with a NNT to prevent one error of 1.6 (95% CI: 1.57-1.64). After adjusting for potential confounders, partnered pharmacist medication charting (beta = -0.78; p<0.001), ATS category (using ATS of 1 as baseline) of 2 (beta= -1.8; p=0.005), ATS category of 3 (beta=-2.1, p=0.001), ATS category of 4 (beta=-1.7; p=0.008) and site number 4 (beta = -1.2; p<0.001 using site number 1 as baseline) were independently associated with reduced length of inpatient hospital stay. The Charlson comorbidity index (beta = 0.2, p<0.001) and the number of regular medications (beta = 0.04, p= 0.013), were independently associated with increased length of inpatient hospital stay. The results of the regression indicated the predictors explained 2.6% of the variance (R^2 =0.026, $F(14,8501)=16.38$, p<0.001).

Discussion

This multi-centre study identified that early intervention with a PPMC model in general medical patients significantly reduced median in-hospital length of stay and medication errors. Feasibility and effectiveness of translation of the model concurrently to multiple institutions was demonstrated. The model reduced the proportion of patients with at least one medication error from 66% to 3.6% with a NNT to prevent one error being 1.6 (95% CI: 1.57-1.64).

Length of stay in hospitals is often used as an indicator of efficiency. All other things being equal, a shorter stay will reduce the cost per discharge and shift care from inpatient to less expensive post-acute settings. Patients may experience extensions in hospitalisations due to delays in decision-making by providers while they wait for results, schedule diagnostic tests, conduct discharge planning, or wait for consultation because of inadequate access to consultants and specialists. [12] It is possible that errors of prescription or omission may contribute to increased length of stay.

There are no other studies in the literature evaluating the impact of a collaborative medication charting model between a medical officer and a pharmacist. The PPMC model, however, consists of several components, including early medication history taking, medication reconciliation, collaborative decision making between the pharmacist and medical officer at the point of admission, and pharmacist charting of medications. The effect of early in-hospital pharmacist-led medication review on the health outcomes of high-risk patients has previously been investigated in an emergency department triage pathway.[13] Hohl et al. identified that early pharmacist-led medication review in high-risk emergency department patients was associated with a trend towards reduced hospital-bed utilisation. In another smaller study conducted in 5 adult medical wards in a single hospital LOS tended to be lower in patients that received medication reconciliation within 24 hours of admission although statistical significance was not demonstrated. Our multi-centre study demonstrated the impact of early review of medications by a pharmacist to reduce length of stay in hospital. It is conceivable that the partnered pharmacist charting model contributes to a reduction in inpatient LOS by improving the timely delivery of appropriate therapy immediately upon the patient's admission. The Victorian Statewide trend in reduction in length of stay for medical patients during the study period was 0.07 days.[16] A reduction in length of stay by 0.5 days is of economic significance in an era where the cost of delivering acute inpatient care is continuing to rise and the average cost per day for emergency admitted patients in Victoria is approximately $1,890. [15] On average, one pharmacist would be expected to undertake the PPMC model for 5 to 10 patients per day. This equates to potential savings of $4725 to $9450 per pharmacist per day, with the estimated average cost of a pharmacist of $460 per day. [17]

The medication error rates in the setting of standard medical charting observed in the pre-intervention phase of this study were consistent with the previously reported randomised trial [10] and previously published literature. [18-20] Potential factors associated with such errors may be the multiple tasks provided by junior medical officers in the setting of an acute admission and the often limited history available from patients who are acutely unwell. Pharmacists are well placed as medication experts to work collaboratively with the medical team to optimise medication therapy at the time of admission.

A limitation to this study is the pharmacy services to GMUs at the seven institutions that participated in this study are not 24 hour-a-day services and only a small proportion (10%) of patients admitted to the GMUs during the intervention phase underwent PPMC. In this study, the pre-intervention phase included patients admitted at any time of the day and the intervention phase only included patients admitted during pharmacist working hours. A previous evaluation of this model identified that there was no difference in the medication error rate for patients admitted during pharmacist working hours or after hours. [10] Clinicians identifying errors on both arms were not blinded, but data were collected using explicit methodology and a blinded multidisciplinary expert panel retrospectively reviewed a proportion of errors to assign a risk rating. In addition, this model is only relevant to settings where pharmacists are not endorsed to prescribe. This study was not randomised as a previously published randomised trial had demonstrated the efficacy of the PPMC model and the purpose of this study was to assess the feasibility of expanding the same model to multiple health services. There are

potentially many unknown confounders in the association between PPMC and hospital LOS that remained unassessed.

The results of our study raise the critical question of whether this model may realise maximal benefit if pharmacy services across Victoria and Australia are provided beyond traditional office hours. Consideration should be given to implementation and evaluation of the partnered pharmacist charting model that operates around the clock. Expansion of the partnered pharmacist charting model across multiple organisations is feasible and effective. Implementation of this model to other clinical areas such as surgical and oncology services should also be considered and evaluation of the impact on electronic prescribing systems on this model should be investigated. Following the results of this study, a National credentialing program for partnered pharmacist charting is being implemented and further expansion of this model across Victoria is planned.

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Table 1: Patient demographics and clinical characteristics

	Pre-intervention N= 5612	Intervention N= 3036	P
Study Site			<0.001
1	492 (9.0%)	467 (15.5%)	
2	1072 (19%)	673 (22.0%)	
3	1162 (21%)	577 (19.0%)	
4	369 (6.5%)	165 (5.5%)	
5	856 (15.0%)	474 (15.5%)	
6	841 (15.0%)	316 (10.5%)	
7	820 (14.5%)	364 (12.0%)	
Age (years)- mean (SD)	74.0 (SD 16.7)	75.3 (SD 15.6)	<0.001
Male sex	2634 (47.0%)	1350 (44.5%)	0.03
Australasian Triage Scale (Maximum waiting time for medical assessment)			0.007
1 (Immediate)	75 (1.3%)	33 (1.1%)	
2 (10 minutes)	994 (17.7%)	593 (19.5%)	
3 (30 minutes)	2910 (52%)	1520 (50.0%)	
4 (60 minutes)	1491 (26.6%)	804 (26.5%)	
5 (120 minutes)	61(1.0%)	56 (1.9%)	
Unknown	81 (1.4%)	30 (1.0%)	
Charlson comorbidity	5 (3-7)	5 (4-7)	0.08
Number of regular medications at admission	8 (4-11)	8 (5-11)	<0.001

Table 2: key results

	Pre-intervention patients N= 5612	Intervention (PPMC patients) N= 3036	p
Number of medications charted	53,371	31,658	
Median Length of Stay (LOS)	4.7 days	4.2 days	p<0.001
Number of patients with at least one medication error (%)	3701 (66%)	111 (3.6%)	p<0.001

Table 3: Risk stratification of medication errors

Risk stratification	Pre-intervention phase errors N= 1020/10233 (10% sample)	Intervention phase errors N=130
Insignificant	132 (13%)	16 (12%)
Low	319 (31%)	58 (45%)
Moderate	298 (29%)	29 (22%)
High	268 (26.5%)	27 (21%)
Extreme	3 (0.5%)	0