Received: 14 May 2019 | Revised: 25 August 2019 | Accepted: 2 September 2019

DOI: 10.1111/bcp.14128

ORIGINAL ARTICLE

Multi-site evaluation of partnered pharmacist medication charting and in-hospital length of stay

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Funding information
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Aims: To undertake a multicentre 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.

Methods: Unblinded, prospective cohort study comparing patients before and after the intervention. Conducted in seven public hospitals in Victoria, Australia from 20 June 2016 to 30 June 2017. Patients admitted to general medical units were included in the study. Medication charting by pharmacists using a partnered pharmacist model was compared to traditional medication charting. The primary outcome variable was the length of inpatient hospital stay. Secondary outcome measures were medication errors detected within 24 h of the patients' admission, identified by an independent pharmacist assessor.

Results: A total of 8648 patients were included in the study. Patients who had PPMC had reduced median length of inpatient hospital stay from 4.7 (interquartile range 2.8–8.2) days to 4.2 (interquartile range 2.3–7.5) days ($P < 0.001$). PPMC was associated with a reduction in the proportion of patients with at least 1 medication error from 66% to 3.6% with a number needed to treat to prevent 1 error of 1.6 (95% confidence interval: 1.57–1.64).

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

KEYWORDS

internal medicine, medication error, medication safety, pharmacist, prescribing

1 | 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 (GMUs) 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

Trial registration: Australian New Zealand Clinical Trials Registry (ACTRN12616000961448).

The authors confirm that the Principal Investigator for this paper is Professor Michael Dooley and that he had direct clinical responsibility for patients.

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(e.g. similar sounding names, low therapeutic index) and patient factors. Strategies to reduce harm include use of information technology, clear medication labelling 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 multicentre evaluation of the effectiveness of the PPMC model in patients admitted to GMUs in 7 public hospitals in the state of Victoria, Australia.

What is already known about this subject

- 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 labelling 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.

2 | METHODS

The evaluation took place in GMUs in 7 public hospitals in Victoria and was funded by the Department of Health and Human Services, Victoria, Australia. Patients were included from the following hospitals: Barwon Health, Eastern Health (Box Hill Hospital and Maroondah Hospital), Echuca Regional Health, The Royal Melbourne Hospital, Monash Health (Monash Medical Centre and Dandenong Hospital). Public hospitals in Australia are primarily government funded. Of the included sites, 1 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 (Alfred Hospital) 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 preintervention cohort included patients who had their medication chart written in the period 20 June 2016 to 24 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 h of admission.

The postintervention cohort included patients who had their medication chart written in the period following the introduction of the PPMC model in the period 25 September 2016 to 30 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. The VTE risk assessment involves assessing a patient's risk of VTE 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 preadmission 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 h, 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 programme 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 programme that included a case-based objective structured clinical examination with a general physician and senior pharmacist. As part of the implementation of the PPMC model

across 7 new sites, the lead site was responsible for credentialing both a medical consultant and senior pharmacist to perform the credentialing process including the objective structured clinical examination 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 h 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 1 in 10 errors in the preintervention 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 h 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 preintervention 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 (interquartile range). Statistical significance was defined by a *P*-value of <.05. Differences in the secondary outcome were presented using relative risk of an error and the number needed to treat (NNT) to prevent 1 error. A per-protocol analysis was performed comparing patients in the preintervention cohort to patients that received the intervention in the postintervention cohort. Statistical significance of difference in means was evaluated using the Student *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, TX, USA).

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 preintervention cohort to be 5.0 (standard deviation 3.0) days and using a power of 90% and a 2-sided significance (α) level of 0.05, the total sample size required was 6054, with 3027 in each arm.

TABLE 1 Patient demographics and clinical characteristics

	Preintervention *n* = 5612	Intervention *n* = 3036	*P*
Study site			<.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 (y), mean (standard deviation)	74.0 (16.7)	75.3 (15.6)	<.001
Male sex	2634 (47.0%)	1350 (44.5%)	.03
Australasian triage scale (maximum waiting time for medical assessment)			.007
1 (immediate)	75 (1.3%)	33 (1.1%)	
2 (10 min)	994 (17.7%)	593 (19.5%)	
3 (30 min)	2910 (52%)	1520 (50.0%)	
4 (60 min)	1491 (26.6%)	804 (26.5%)	
5 (120 min)	61(1.0%)	56 (1.9%)	
Unknown	81 (1.4%)	30 (1.0%)	
Charlson comorbidity index	5 (3–7)	5 (4–7)	.08
Number of regular medications at admission	8 (4–11)	8 (5–11)	<.001

3 | RESULTS

In the preintervention phase, 5612 patients were admitted to the 7 GMUs and received standard medical officer medication charting and medication reconciliation by a pharmacist. A total of 27 924 patients were admitted to the 7 GMUs during the intervention period. Of these, 3036 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 preintervention (medical charting) cohort and 31 658 in the intervention (PPMC) cohort.

The median (interquartile range) LOS was 4.7 days (2.8–8.2) in the preintervention phase and 4.2 days (2.3–7.5) among patients that received PPMC (*P* < .001; Table 2). Of the 5612 patients who received standard medical charting during the preintervention period, 3701 (66%) had at least 1 medication error identified compared to 111 patients (3.6%) using PPMC (*P* < .001).

TABLE 2 Key results

	Preintervention patients *n* = 5612	Intervention (PPMC patients) *n* = 3036	*P*
Number of medications charted	53 371	31 658	
Median length of stay	4.7 days	4.2 days	<.001
Number of patients with at least 1 medication error (%)	3701 (66%)	111 (3.6%)	<.001

TABLE 3 Risk stratification of medication errors

Risk stratification	Preintervention phase errors *n* = 1020/10 233 (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

A total of 1020 errors from the 10 233 errors identified in the preintervention 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 1 error with PPMC was 0.11 (95% confidence interval [CI]: 0.09–0.13) with a NNT to prevent 1 error of 1.6 (95% CI: 1.57–1.64). After adjusting for potential confounders, partnered pharmacist medication charting (β = −0.78; P < .001), Australasian Triage Scale (ATS) category (using ATS of 1 as baseline) of 2 (β = −1.8; P = .005), ATS category of 3 (β = −2.1, P = .001), ATS category of 4 (β = −1.7; P = .008) and site number 4 (β = −1.2; P < .001 using site number 1 as baseline) were independently associated with reduced length of inpatient hospital stay. The Charlson comorbidity index (β = 0.2, P < .001) and the number of regular medications (β = 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 < .001).

4 | DISCUSSION

This multicentre 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 1 medication error from 66 to 3.6% with NNT to prevent 1 error being 1.6 (95% CI: 1.57–1.64).

LOS 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 LOS.

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 h of admission although statistical significance was not demonstrated. Our multicentre 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 state-wide trend in reduction in LOS for medical patients during the study period was 0.07 days.[16] A reduction in LOS 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 $1890.[15] On average, 1 pharmacist would be expected to undertake the PPMC model for 5–10 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 preintervention 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 that the pharmacy services to GMUs at the 7 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 preintervention 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 PPMC model that operates around the clock. Expansion of the PPMC 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 programme for PPMC is being implemented and further expansion of this model across Victoria is planned.

COMPETING INTERESTS

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

CONTRIBUTORS

E.T.: study design, data management, data analysis, manuscript development, and manuscript review. M.D., G.Y., B.M., K.G.: study design, data analysis, and manuscript review. C.R., D.S., H.G., H.N., S.K., G. W., N.J., P.T., C.T., P.H., D.T.: study design and manuscript review.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Buckley MS, Harinstein LM, Clark KB, et al. Impact of a clinical pharmacy admission medication reconciliation program on medication errors in "high-risk" patients. *Annals of Pharmacotherapy*. 2013;47(12):1599-1610.
2. Hughes CF. Medication errors in hospitals: what can be done? *Medical Journal of Australia*. 2008;188(5):267-268.
3. Hanlon JT, Pieper CF, Hajjar ER, et al. Incidence and predictors of all and preventable adverse drug reactions in frail elderly persons after hospital stay. *J Gerontol a Biol Sci Med Sci*. 2006;61(5):551-555.
4. Hajjar ER, Cafiero AC, Hanlon JT. Polypharmacy in elderly patients. *Am J Geriatr Pharmacother*. 2007;5(4):345-351.
5. Hohl CM, Dankoff J, Colacone A, Afilalo M. Polypharmacy, adverse drug-related events, and potential adverse drug interactions in elderly patients presenting to an emergency department. *Ann Emerg Med*. 2001;38(6):666-671.
6. Wittich CM, Burkle CM, Lanier WL. Medication errors: an overview for clinicians. *Mayo Clin Proc*. 2014 Aug;89(8):1116-1125.
7. Ryan C, Ross S, Davey P, et al. Prevalence and causes of prescribing errors: the PRescribing outcomes for trainee doctors engaged in clinical training (PROTECT) study. *PLoS One*. 2014 Jan 3;9(1):e79802.
8. Australian Council on Safety and Quality in Health Care. *Second national report on improving patient safety: improving medication safety*. Canberra: Australian Council on Safety and Quality in Health Care; 2002.
9. Tong EY, Roman CP, Newnham H, Galbraith K, Dooley MJ. Partnered medication review and charting between the pharmacist and medical officer in the emergency short stay and general medicine unit. *Australasian Emergency Nursing Journal*. 2015 Aug;18(3):149-155. https://doi.org/10.1016/j.aenj.2015.03.002
10. Tong EY, Roman C, Mitra B, et al. Partnered pharmacist charting on admission in the general medical and emergency short-stay unit - a cluster-randomised controlled trial in patients with complex medication regimens. *J Clin Pharm Ther*. 2016 Aug;41(4):414-418.
11. Taylor G, Leversha A, Archer C, et al. Standards of practice for clinical pharmacy services. *J Pharm Pract Res*. 2013;43(2):S2-S69.
12. Selker HP, Beshanky JR, Pauker SG, Kassirer JP. The epidemiology of delays in a teaching hospital. *Med Care*. 1989;27:112-129.
13. Hohl CM, Partovi N, Ghement I, et al. Impact of early in-hospital medication review by clinical pharmacists on health services utilization. *PLoS ONE*. 2017;12(2):e0170495.
14. Cadman B, Wright D, Bale A, et al. Pharmacist provided medicines reconciliation within 24 hours of admission and on discharge: a randomised controlled pilot study. *BMJ Open*. 2017;7(3):e013647. https://doi.org/10.1136/bmjopen-2016-013647
15. Independent Hospital Pricing Authority [Internet]. National Hospital Cost Data Collection, Public Hospitals Cost Report, Round 20 (Financial year 2015–16): February 2018 [cited 19 Dec 2018]. Available from https://www.ihpa.gov.au/publications/national-hospital-cost-data-collection-public-hospitals-cost-report-round-20-0
16. Department of Health and Human Services, Victoria, Health Workforce Innovation and Reform [Internet]. Health Economic Evaluation of the Partnered Pharmacist Medication Charting (PPMC) program [cited 21 Aug 2019]. Available from https://www2.health.vic.gov.au/health-workforce/reform-and-innovation/partnered-pharmacist-medication-charting

17. Victorian Public Health Sector (Medical Scientists, Pharmacists & Psychologists) enterprise agreement 2017–2021 [cited 08 July 2019]. Available from http://vhia.com.au/docs/default-document-library/bul-2223-attachement-a.pdf?sfvrsn=2
18. Barton L, Futtermenger J, Gaddi Y, et al. Simple prescribing errors and allergy documentation in medical hospital admissions in Australia and New Zealand. *Clin Med*. 2012;12(2):119-123.
19. Lewis PJ, Dornan T, Taylor D, Tully MP, Wass V, Ashcroft DM. Prevalence, incidence and nature of prescribing errors in hospital inpatients. *Drug Saf*. 2009;32(5):379-389.
20. Weeks GR, Ciabotti L, Gorman E, Abbott L, Marriott JL, George J. Can a redesign of emergency pharmacist roles improve medication management? A prospective study in three Australian hospitals. *Research in Social and Administrative Pharmacy*. 2014;10(4):679-692.

How to cite this article: Tong EY, Mitra B, Yip G, Galbraith K, Dooley MJ, PPMC Research Group. Multi-site evaluation of partnered pharmacist medication charting and in-hospital length of stay. *Br J Clin Pharmacol*. 2020;86:285–290. https://doi.org/10.1111/bcp.14128