INCIDENCE OF CLINICALLY RELEVANT MEDICATION ERRORS AFTER IMPLEMENTATION OF AN ELECTRONIC MEDICATION RECONCILIATION PROCESS

Kaitlin R. Stockton MD,[1] Maeve E. Wickham MSc,[2] Simon Lai BSc,[3] Katherin Badke BScPharm,[4] Karen Dahri PharmD,[4,5] Diane Villanyi MD FRCP(C)[6], Vi Ho MD,[7] Corinne M. Hohl MD FRCP(C)[2,7]

1. Department of Family Medicine, University of British Columbia - 3rd Floor David Strangway Building, 5950 University Boulevard, Vancouver, BC, V6T 1Z3
2. Department of Emergency Medicine, University of British Columbia, 855 West 12th Avenue, Vancouver, BC V5Z 1M9
3. Faculty of Medicine, University of British Columbia, 317 - 2194 Health Sciences Mall, Vancouver, BC V6T 1Z3
4. Department of Pharmaceutical Sciences, Vancouver General Hospital, 855 West 12th Avenue, Vancouver, BC, V5Z 1M9
5. Faculty of Pharmaceutical Sciences, University of British Columbia, 2405 Westbrook Mall, Vancouver, BC V6T 1Z3
6. Department of Internal Medicine, Vancouver General Hospital, 855 West 12th Avenue, Vancouver, BC V5Z 1M9
7. Emergency Department, Vancouver General Hospital; 920 West 10th Ave, Vancouver, BC V5Z 1M9

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Author Contact: krgraham@telus.net

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ABSTRACT (249/250)

Background: Medication discrepancies are unintended differences between a patient's outpatient and inpatient medication regimens, and occur in up to 60% of hospital admissions. In order to reduce medication discrepancies, Canadian institutions have implemented medication reconciliation forms that are pre-populated with outpatient medication dispensing data. However, these have the potential to introduce errors of commission by prompting prescribers to reorder discontinued medications or continue medications that are contraindicated. Our objective was to evaluate the incidence of medication discrepancies and errors of commission after the implementation of such forms.

Methods: This retrospective chart review included patients previously enrolled in an observational study in which a research pharmacist prospectively collected best-possible medication histories (BPMHs) in the emergency department (ED). Following discharge from hospital, research assistants uninvolved with the parent study compared medication orders written in the first 48h of admission with the research pharmacist's BPMH to identify medication discrepancies and errors of commission. Errors of commission were defined as inappropriate continuations of medications and reordering medications previously stopped. An independent panel adjudicated their clinical significance.

Results: Among 151 patients, 71 (47%; 95% confidence interval [CI] 39.2-54.9) were exposed to 112 medication errors on admission. Of these errors, 75.9% (85/112; 95%CI 67.1-82.9) were medication discrepancies, of which 18.8% (16/85; 95%CI 12.0.-28.4) were clinically significant. Errors of commission made up 24.1% of all errors (27/112; 95%CI 17.3-32.8), of which 37.0% were clinically significant (10/27, 95%CI 18.8-55.2).

Interpretation: Medication discrepancies and errors of commission remain common despite the implementation of electronically pre-populated medication reconciliation forms.

INTRODUCTION (2419/2500)

Medication discrepancies are unintended differences between a patient's outpatient and inpatient medication regimens, and affect up to 60% of patients admitted to Canadian hospitals. They have the potential to lead to adverse drug events, unintended and harmful effects associated with medications,(1-3) which are a common cause of preventable iatrogenic morbidity and mortality.(4-6)

Medication reconciliation is a required organizational practice in Canadian hospitals.(7) It involves obtaining and documenting a BPMH upon admission in order to improve communication at care transition points and prevent medication discrepancies.(7) Several international studies have demonstrated a reduction in medication discrepancies in hospitalized patients following the implementation of medication reconciliation interventions.(8-14) However, the majority of published interventions relied heavily on pharmacist involvement, limiting their generalizability to institutions with adequate pharmacy resources. Most Canadian hospitals lack such pharmacy manpower, and rely on physicians, nurses, and clinical trainees to complete medication reconciliation processes, even though these individuals often lack the time to conduct thorough medication histories.(15-18).

In order to facilitate medication history-taking and eliminate transcribing errors, hospitals in jurisdictions with access to electronic medication dispensing records have developed medication reconciliation forms that are pre-populated with outpatient medication dispensing data. Yet, such databases do not capture medications dispensed outside of community pharmacies (*e.g.,* in long-term care facilities), retain information on

discontinued medications, and may list inaccurate doses of medications titrated by patients or care providers (e.g., warfarin).(19,20) Therefore, pre-populated medication reconciliation forms have the potential to introduce errors of commission by prompting healthcare providers to restart a discontinued medication, or continue a medication in the setting of a new contraindication. Our objective was to evaluate the incidence of medication discrepancies and errors of commission after implementation of an electronically pre-populated medication reconciliation form. A secondary objective was to evaluate factors associated with both types of errors.

METHODS

Design

We conducted a structured two-staged chart review at Vancouver General Hospital, a 955-bed academic tertiary care center. This was an *a priori* planned sub-study of a large prospective observational cohort study that aimed to validate a clinical decision rule to identify patients at high-risk for adverse drug events. The University of British Columbia Clinical Research Ethics Board approved the study protocol, and waived the need for informed consent.

Participants

We enrolled patients into the prospective study who presented to the ED, were 19 years of age or older, spoke English or had a translator available, and had ingested at least one prescription or over-the-counter medication within two weeks.(21) We included patients who had been enrolled into the prospective study and were subsequently admitted to hospital between October 1st 2014 and August 31st 2015. We excluded patients whose charts were unavailable for review and those with admissions lasting under 24 hours.

Definitions

We defined a medication discrepancy as any unexplained difference between medication orders documented on completed medication reconciliation forms or other order sheets within the first 48 hours of admission, and the BPMH as recorded by the research pharmacist. Discrepancies included discontinuations and omissions of home medications; changes in the dose, route, or frequency of administration; ordering a *PRN* medication

regularly or vice versa (Table 1). We defined an error of commission as reordering a medication that had been previously stopped, or inappropriately continuing a medication known to exacerbate a patient's presenting clinical condition (*e.g.* continuing an antihypertensive in the setting of hypotension). We did not consider substituting a brand name medication for its generic equivalent or an agent within the same pharmacologic class as discrepancies. We excluded discrepancies involving herbal products, vitamins, and supplements.

We rated clinical severity based on a previously published classification system: Class I errors were those deemed "unlikely to cause patient discomfort or clinical deterioration".(1) Class II errors had "the potential to cause moderate discomfort or clinical deterioration". Class III errors were defined as having "the potential to result in severe discomfort or clinical deterioration".

BPMH Data Collection

During the prospective study, a research pharmacist (KB) collected and documented BPMHs in the ED using a variety of information sources including patient and family member interviews, PharmaNet (British Columbia's electronic medication dispensing database), nursing home medication records, medication bottles, blister packs, and collateral sources of information if required. We retained pharmacist-collected BPMHs in the research records of the parent study, and considered it to be the gold standard.

Chart Review Methods

Stage 1

Following discharge from hospital, two research assistants (KG & SL) uninvolved in the parent study and blinded to the BPMH collected by the research pharmacist, reviewed the charts of eligible patients. They abstracted all medication orders written within 48 hours of admission, including those documented on medication reconciliation forms (Figure 1) and regular order sheets, using a standardized form. Both research assistants independently reviewed a random sample of 20 charts during a pilot period in order to assess inter-rater reliability. They recorded demographic data and clinical information pertaining to the admission. All data was collected using EpiInfo software (version 7.1.4).

Stage 2

One of the research assistants (KG), a medical resident, then compared admission orders identified during stage 1 with the research pharmacist's BPMH, and documented medication discrepancies and errors of commission. We excluded medication discrepancies that were appropriate (*e.g.,* holding diabetic medication in the setting of hypoglycemia), as determined by chart review.

Stage 3

An independent committee consisting of an internist and geriatrician (DV), an emergency physician (CMH), and a clinical pharmacist (KD), all of whom were uninvolved in stages 1 and 2, adjudicated inappropriate discrepancies and errors of commission according to their potential to cause harm. During the pilot process for adjudication (20 charts), it became apparent that we could not determine intentionality retrospectively. Therefore,

we categorized inappropriate discrepancies as “unexplained” or “explained”, as determined by review of clinical notes. Only unexplained inappropriate discrepancies were considered errors for the purposes of this study. Explained inappropriate discrepancies were considered bad prescribing, and were not an outcome measure of our study. All disagreements were resolved by discussion. We calculated the inter-rater reliability among the three members of the adjudication panel for classifying the type and severity of errors by collapsing class II and III discrepancies into a single category.

Statistical Analysis

We computed descriptive statistics for demographic variables and medication error classifications, and reported summary statistics as means and standard deviations for continuous variables, and as proportions with 95% CIs for categorical variables. We assessed the agreement between raters by calculating Fleiss’ kappa scores with 95% CIs.(22) We analyzed the association between unexplained discrepancies and potentially important variables using non-parametric Mann-Whitney U tests, as the outcome data did not follow a normal distribution. Potentially important variables were determined by a literature review on medication discrepancies and adverse drug events.(1,23) We used logistic regression to examine univariate associations between the occurrence of a discrepancy and key predictor variables, then built a regression model to calculate the adjusted odds of a discrepancy occurring. The sample size was determined by the primary study.

RESULTS

Main Results

Of 189 patients enrolled in the primary study who were admitted to hospital, 151 met our study's inclusion criteria (Figure 2). Twenty-seven charts were not available for review, 8 were admitted for less than 24 hours, and 3 had an incomplete BPMH. The mean age of participants was 66.8 (SD 18.8) and 52.9% (80/151) were male (Table 2). The mean number of medications on admission was 6.8 (SD 4.7), and the most common admitting diagnoses were pneumonia, cancer, and sepsis.

The inter-rater reliability between research assistants in documenting medication orders was 0.91 (95%CI κ=0.78-1.0). Eight patients did not have a pre-populated medication reconciliation form in their chart. Among the 143 charts containing medication reconciliation forms, only 32.1% (46/143; 95%CI 25.0-40.2) had a completed medication history section (*i.e.*, middle column of the form; Figure 1). Among charts in which the medication history section was completed, 39.1% (18/46; 95%CI: 26.4-53.6) were completed by residents, 26.1% (12/46; 95%CI 15.6-40.3) by clinical pharmacists, 13.0% (6/46; 95%CI 6.2-25.7) by attending physicians, 19.6% (9/46; 95%CI 10.7-3.3.2) by medical students, and 2.2% (1/46; 95%CI 0.5-11.2) by a nurse.

Incidence of Medication Errors

Among 151 patients, 71 (47%; 95%CI 39.2-54.9) were exposed to 112 medication errors on admission (Figure 2). We identified 85 unexplained medication discrepancies in 49 patients (49/151; 32.5%, 95%CI: 25.0-40.0; Table 3). The majority of discrepancies were

categorized as inappropriate discontinuations (32/85; 37.6%, 95%CI 27.3-47.9) and omissions (24/85; 28.2%, 95%CI 18.6-37.8). Twenty-two patients had at least one error of commission (22/151; 14.6%, 95%CI 9.0-20.2). Errors of commission accounted for 24.1% of all medication errors (27/112; 95%CI 16.2-32.0). These included ten inappropriate continuations (10/27; 37.0%, 95%CI 21.5-55.9) and 17 reorder errors (17/27; 62.9%, 95%CI 44.1-78.5).

Clinical Significance

The inter-rater reliability among the three members of the adjudication panel for classifying the severity of errors was 0.33 (95%CI κ=0.28-0.42). Only 17.6% of discrepancies (15/85; 95%CI 9.5-25.7) were deemed as having the potential to cause moderate harm (class II), and one (1.2%, 95%CI 0.0-3.5) was classified as having the potential to result in severe clinical deterioration (class III; Table 3). Among identified errors of commission, 37.0% (10/27; 95%CI 18.8-55.2) were assigned a class II rating, and none were assigned a class III rating. Of the clinically significant (Class II and III) errors, twenty-five percent (6/24; 95%CI 12.1-45.1) involved continuing a patient's antihypertensive medication in the setting of symptomatic hypotension and 16.6 % (4/24; 95%CI 6.8-36.1) were an omission of low dose aspirin (Table 4). We found no documented adverse drug events as a result of medication errors.

Factors Associated with Medication Errors

Univariable analysis indicated that taking eight or more medications and the presence of cognitive impairment were associated with unexplained discrepancies ($p<0.001$, $p=0.05$

respectively; Table 5). Similarly, taking eight or more medications was associated with errors of commission ($p = 0.02$).

Multivariable analyses indicated that taking eight or more medications was associated with a five-fold greater odds of experiencing one or more medication discrepancies or errors of commission (OR: 5.00, 95%CI: 2.45-10.17, $p < 0.001$) after controlling for known confounders (Table 6). Age, gender, timing of and length of admission were not associated with the occurrence of either medication errors or errors of commission.

INTERPRETATION

Our objective was to evaluate the incidence of clinically relevant medication discrepancies and errors of commission after the implementation of pre-populated medication reconciliation forms. We found at least one medication discrepancy or error of commission in 47% of enrolled patients. Errors of commission occurred in 14.6% of patients, and 37% were clinically significant. The medication history section of pre-populated medication reconciliation forms was left blank in 67.9% of the charts we reviewed. To our knowledge, this is the first Canadian study to examine the incidence of clinically significant medication discrepancies and errors of commission after the implementation of a medication reconciliation form that incorporates electronic medication-dispensing data.

We found a lower incidence of medication discrepancies overall (32.5% versus 53.6%) and of clinically significant discrepancies (18.8% versus 38.6%) compared to Cornish et al. who conducted a prospective study in a Canadian teaching hospital without access to electronic medication dispensing data.(1) Kalb et al conducted a prospective study following the launch of PharmaNet, but prior to the implementation of pre-populated medication reconciliation forms, and reported discrepancies in 60% of inpatients, 43% of which were deemed clinically significant.(2) International studies with varied methodologies have described unintentional medication discrepancies in 27-54% of patients, 11-59% of which were deemed to be clinically important.(5,6,24)

We report a high incidence of errors of commission compared to Cornish et al. (24.1% versus 0%).(1) This is similar to the 27% commission error proportion reported by Kalb

et al after PharmaNet data became available to hospital prescribers.(2) This may be a reflection of an overreliance on dispensing data by prescribers in lieu of taking a careful medication history, which may be compounded by the ease of ticking boxes on pre-populated forms. In our study, 37% of commission errors were rated as having the potential to cause at least moderate harm. Therefore, while pre-populated medication reconciliation forms may reduce medication discrepancies, our data suggest that they may potentiate errors of commission that may be as, or potentially more, harmful.

Most patients in our study did not have a medication history documented on the medication reconciliation form, and only 12 patients had medication histories documented by a clinical pharmacist. Several studies demonstrate a reduction in both overall and clinically significant medication discrepancies when clinical pharmacists are involved in reconciling medications.(3,14,25,26). Given the scarcity of pharmacist resources, it is likely only feasible for clinical pharmacists to assess patients who are at highest risk for medication errors. Based on our study, this may include patients taking at least eight medications and those with cognitive impairment. Our data are consistent with a recent Canadian study which noted a significant increase in medication discrepancies among patients prescribed at least seven medications upon discharge.(27)

Our study has several limitations. Sample size was limited by enrollment into the parent study. Our study was retrospective. We were therefore unable to confirm intentionality for the identified discrepancies when clinical notes were unclear. While the inter-rater reliability on the collection of the medication orders was excellent, the inter-rater reliability on rating their clinical significance was only fair. This likely reflects the varied clinical backgrounds of our adjudication team members. Although we used a

prospectively collected BPMH obtained by a research pharmacist as our gold standard, this information was obtained when many patients were ill and it is possible that errors occurred during this process. This study was conducted at a large teaching hospital and may not be generalizable to community settings. Finally, medication discrepancies and errors of commission may result from different patient and/or hospital factors, and should therefore be investigated separately in future studies with larger sample sizes.

We conclude that despite the implementation of a medication reconciliation process informed by electronic medication dispensing data, clinically relevant medication errors remain common. We witnessed the presence of clinically significant errors of commission due to reordering medications that had previously been stopped and continuing medications that had the potential to cause harm. Prospective studies are needed to confirm our findings, and to evaluate whether the benefit of reducing medication discrepancies using pre-populated medication reconciliation forms is offset by the possible risk of introducing errors of commission. Our results highlight that the availability of medication dispensing data to inform medication reconciliation does not negate the need to conduct and document a thorough BPMH. Future research is needed to identify patients who are at the highest risk of medication discrepancies and errors of commission in order to maximize scarce pharmacist resources and develop more effective preventive strategies.

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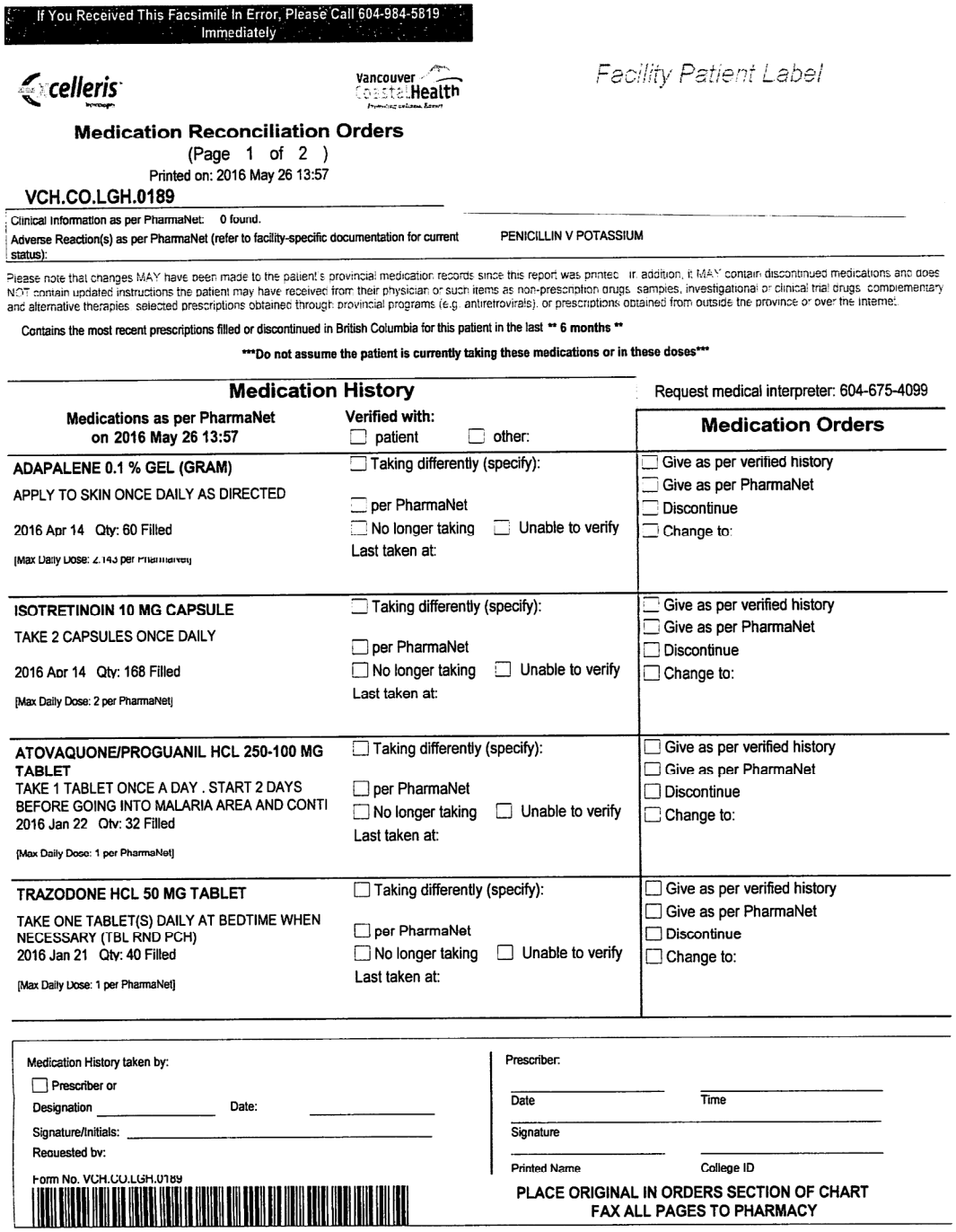
Figure 1: Prepopulated Medication Reconciliation Form

Electronic medication dispensing data from Pharmanet is used to automatically pre-populate medication reconciliation forms. A member of the healthcare team must verify the patient's medication history and note any discrepancies between the pre-populated information and how the patient is taking the medication in the middle column. The treating physician then indicates whether or not to continue or alter the medication in the right-hand column.



If You Received This Facsimile In Error, Please Call 604-984-5819 Immediately

celleris | Vancouver Coastal Health

Facility Patient Label

Medication Reconciliation Orders

(Page 1 of 2)

Printed on: 2016 May 26 13:57

VCH.CO.LGH.0189

Clinical Information as per PharmaNet: 0 found.

Adverse Reaction(s) as per PharmaNet (refer to facility-specific documentation for current status): PENICILLIN V POTASSIUM

Please note that changes MAY have been made to the patient's provincial medication records since this report was printed. In addition, it MAY contain discontinued medications and does NOT contain updated instructions the patient may have received from their physician or such items as non-prescription drugs, samples, investigational or clinical trial drugs, complementary and alternative therapies, selected prescriptions obtained through provincial programs (e.g. antiretrovirals), or prescriptions obtained from outside the province or over the Internet.

Contains the most recent prescriptions filled or discontinued in British Columbia for this patient in the last ** 6 months **

Do not assume the patient is currently taking these medications or in these doses

Medication History

Request medical interpreter: 604-675-4099

Medications as per PharmaNet on 2016 May 26 13:57	Verified with: ☐ patient ☐ other:	Medication Orders
ADAPALENE 0.1 % GEL (GRAM) APPLY TO SKIN ONCE DAILY AS DIRECTED 2016 Apr 14 Qty: 60 Filled [Max Daily Dose: 2.143 per PharmaNet]	☐ Taking differently (specify): ☐ per PharmaNet ☐ No longer taking ☐ Unable to verify Last taken at:	☐ Give as per verified history ☐ Give as per PharmaNet ☐ Discontinue ☐ Change to:
ISOTRETINOIN 10 MG CAPSULE TAKE 2 CAPSULES ONCE DAILY 2016 Apr 14 Qty: 168 Filled [Max Daily Dose: 2 per PharmaNet]	☐ Taking differently (specify): ☐ per PharmaNet ☐ No longer taking ☐ Unable to verify Last taken at:	☐ Give as per verified history ☐ Give as per PharmaNet ☐ Discontinue ☐ Change to:
ATOVAQUONE/PROGUANIL HCL 250-100 MG TABLET TAKE 1 TABLET ONCE A DAY . START 2 DAYS BEFORE GOING INTO MALARIA AREA AND CONTI 2016 Jan 22 Qty: 32 Filled [Max Daily Dose: 1 per PharmaNet]	☐ Taking differently (specify): ☐ per PharmaNet ☐ No longer taking ☐ Unable to verify Last taken at:	☐ Give as per verified history ☐ Give as per PharmaNet ☐ Discontinue ☐ Change to:
TRAZODONE HCL 50 MG TABLET TAKE ONE TABLET(S) DAILY AT BEDTIME WHEN NECESSARY (TBL RND PCH) 2016 Jan 21 Qty: 40 Filled [Max Daily Dose: 1 per PharmaNet]	☐ Taking differently (specify): ☐ per PharmaNet ☐ No longer taking ☐ Unable to verify Last taken at:	☐ Give as per verified history ☐ Give as per PharmaNet ☐ Discontinue ☐ Change to:

Medication History taken by:

☐ Prescriber or

Designation _____ Date: _____

Signature/Initials: _____

Requested by:

Form No. VCH.CO.LGH.0189

Prescriber:

Date _____ Time _____

Signature _____

Printed Name _____ College ID _____

PLACE ORIGINAL IN ORDERS SECTION OF CHART

FAX ALL PAGES TO PHARMACY

Figure 2. Patient Flow Diagram

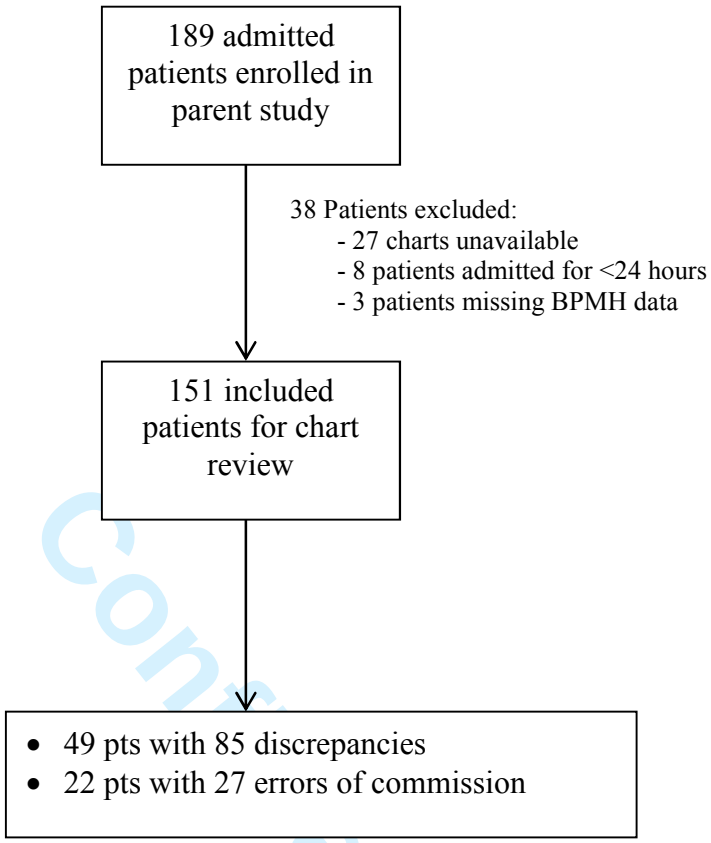


Table 1. Categories of Medication Errors

Type of Error	Definition	Example
Medication Discrepancies		
Discontinuation	Discontinuing a patient's regular medication without explanation	A patient was taking 20mg of citalopram at home, but this was discontinued upon admission to hospital
Omission	A patient's regular medication was not listed on the medication reconciliation form, and was not re-ordered	A patient was taking 81mg of ASA (over-the-counter) daily but this was not listed on the medication reconciliation form. It was not ordered during the admission.
Change in Dose	A medication was ordered at the dose indicated on the medication reconciliation form, but the patient was taking a different dose	A patient was prescribed 25 mg metoprolol BID, but the family doctor had decreased the dose to 12.5mg PO BID. The patient received 25mg BID in hospital without an indication for the increased dose.
Change in Route	A medication was ordered using the route indicated on the medication reconciliation form, but the patient was taking it differently at home	A patient was prescribed acetaminophen 1000mg PO TID per rectum in a nursing facility due to a decreased level of consciousness. It was ordered by mouth in-hospital.
Change in frequency	A medication was ordered at the frequency indicated on the medication reconciliation form which differed from the patient's regimen	A patient was prescribed gabapentin 300mg TID but the patient was taking it only qhs due to daytime somnolence. The medication was ordered as 300mg TID in hospital.
PRN to regular	A medication was ordered regularly as per the medication reconciliation form, but the patient was taking it *PRN*	A patient was prescribed zopliclone 7.5mg qhs but the patient was using it on a *PRN* basis, and only infrequenty. It was ordered regularly in-hospital.
Regular to *PRN*	A medication was ordered *PRN* as per the medication reconciliation form, but the patient was taking it regularly	A patient was prescribed lorazepam 0.5-1mg TID *PRN* but was taking 1 mg TID regularly. It was ordered *PRN* while in hospital.
Errors of Commission		
Reorder Error	Reordering a medication that had previously been stopped	A patient was prescribed indomethacin for an acute gout flare, but had stopped it when the flare subsided. It was erroneously re-ordered in hospital.
Inappropriate Continuation	Ordering a medication that a patient is taking in the setting of a new contra-indication.	A patient is taking indomethacin for an acute gout flare, and now presents with a gastrointestinal bleed. Indomethacin is inappropriately continued while in hospital.

Table 2. Characteristics of Study Members

Characteristic	N
Sex (%)	
Male	80 (53.0%)
Female	71 (47.0%)
Age, mean (SD)	66.8 (18.8)
Length of stay in days, median (IQR)	6 (3, 13)
Most responsible diagnoses (SD)	
Pneumonia	14 (9.3)
Cancer	11 (7.3)
Sepsis	9 (6.0)
Stroke Syndrome	8 (5.3)
Extremity Fracture	7 (4.6)
Upper Gastrointestinal Bleed	6 (4.0)
COPD	4 (2.7)
Skin/Soft Tissue Infection	4 (2.7)
Bipolar Affective Disorder	4 (2.7)
Asthma	3 (2.0)
Comorbidities (SD)	
HTN	68 (45.0)
Dyslipidemia	29 (19.2)
Diabetes Mellitus Type 2	25 (16.6)
Atrial Fibrillation	24 (15.9)
Depression/Anxiety	21 (13.9)
Hypothyroidism	21 (13.9)
GERD	20 (13.2)
CAD	19 (12.6)
CHF	18 (11.9)
OA	18 (11.9)
Number of medications on admission, mean (SD)	6.8 (4.7)

Table 3. Type and Potential Severity of Errors

Type of Error	No (%)	Class I	Class II	Class III
Medication Discrepancies				
Discontinuation	32 (37.6)	29 (90.6)	2 (6.3)	1 (3.1)
Omission	24 (28.2)	19 (79.2)	5 (20.8)	0
Change in Dose	15 (17.6)	11 (73.3)	4 (26.7)	0
Change in Route	0	0	0	0
Change in Frequency	6 (7.1)	5 (83.3)	1 (16.7)	0
PRN to regular	6 (7.1)	5 (83.3)	1 (16.7)	0
Regular to *PRN*	2 (2.4)	2 (100.0)	0	0
Total	85 (100)	71 (83.5)	13(15.3)	1 (1.2)
Errors of Commission				
Reordering Error	17 (63.0)	14 (82.4)	3 (1.8)	0
Inappropriate continuations	10 (37.0)	3 (30.0)	7 (70.0)	0
Total	27 (100)	17 (63.0)	10 (37.0)	0

Table 4. Description of Errors Assigned a Class II/III score

Admission Diagnosis	Description of Errors	Type & Clinical Significance
Extremity fracture	• Patient had drug-eluting stent placed within the past year and was taking dual antiplatelet therapy. Aspirin was omitted from admission orders. • Perindopril/Indapamide was ordered on admission, however this medication had been previously stopped and the patient was no longer taking it.	• Omission, Class III • Reorder error, Class II
Upper GI bleed	• The patient's hydrochlorothiazide was reordered despite symptomatic hypotension at presentation. • Gliclazide was ordered on admission, however this medication had been previously stopped and the patient was no longer taking it.	• Inappropriate continuation, Class II • Reorder error, Class II
Pneumonia, COPD	• Patient's budesonide was omitted despite regular use in the setting of severe COPD.	• Omission, Class II
Depression	• The patient's budesonide/formeterol was discontinued on admission orders despite regular use in the setting of severe COPD and asthma. • The patient's prednisone was discontinued on admission orders despite regular use.	• Discontinuation, Class II • Discontinuation, Class II
Syncope	• The patient's hydrochlorothiazide was continued despite symptomatic orthostatic hypotension at presentation.	• Inappropriate continuation, Class II
Schizophrenia	• The patient's zuclopenthixol was ordered as 60mg IM q2weeks as per PharmaNet, however the patient was receiving only taking 40mg IM q2weeks	• Change in dose, Class II
Weakness	• The patient's aspirin was omitted from the admission orders (indication TIAs).	• Omission, Class II
Asthma	• Indomethacin was ordered on admission, however the patient was no longer taking this medication.	• Reorder error, Class II
Dyspnea	• Patient's aspirin was omitted from the admission orders in (indication CAD)	• Omission, Class II
Fall	• Patient's amlodipine was continued despite symptomatic hypotension.	• Inappropriate continuation, Class II
Cancer	• Celecoxib was ordered regularly as per PharmaNet, however the patient took this on a *PRN* basis.	• *PRN* to regular, Class II
Pulmonary embolism	• The patient's metoprolol was continued despite symptomatic hypotension. • The patient's perindopril was continued despite symptomatic hypotension. • The patient's aspirin was omitted from the admission orders (indication CAD).	• Inappropriate continuation, Class II • Inappropriate continuation, Class II • Omission, Class II
Hypovolemia, Atrial Flutter	• Imatinib was ordered on admission as per PharmaNet, however the patient was no longer taking this medication.	• Reorder error, Class II
TIA	• Patient was taking 7.5 mg zopiclone QHS, however it was ordered as 11.25mg QHS *PRN* as per PharmaNet.	• Change in dose, Class II
Pneumonia, Sepsis	• Patient was taking dantrolene 100mg QID but it was ordered as 400mg QID as per PharmaNet.	• Change in dose, Class II
UTI, Sepsis	• Patient was using fluticasone regularly for asthma but this was omitted.	• Omission, Class II
UTI	• Patient was taking carbidopa/levodopa ER TID and QHS *PRN* however this was ordered as once daily as per PharmaNet.	• Change in frequency, Class II
Sepsis	• Patient was taking methadone 3mg Q8H but this was ordered as 2mg Q8H as per PharmaNet.	• Change in dosage, Class II
Pyelonephritis	• The patient's bisoprolol was continued in the setting of symptomatic hypotension	• Inappropriate continuation, Class II

GI=gastrointestinal; COPD=chronic obstructive pulmonary disease; IM=intra-muscular; q2weeks=once every 2 weeks; TIA=transient ischemic attack; CAD=coronary artery disease; PRN=as needed; QHS=every bedtime; QID=4 times per day; UTI=urinary tract infection; ER=extended release; TID=3 times per day.

Table 5. Univariate Association between Patient Characteristics and Errors

Characteristics	Mean Number of Errors Per Patient		Difference (95% CI)	P-value
	With characteristic	Without characteristic		
Medication Discrepancies				
Night time admission (after 8pm)	0.43	0.61	0.19 (-0.19, 0.57)	0.31
Length of stay ≥ 48 hours	0.57	0.46	-0.11 (-0.71, 0.49)	0.89
Age ≥ 80	0.75	0.48	-0.27 (-0.63, 0.08)	0.18
Female sex	0.63	0.50	-0.13 (-0.47, 0.20)	0.34
≥8 Medications on BPMH	1.09	0.24	-0.84 (-1.16, -0.53)	< 0.001
Prepopulated Med Rec Form	0.55	0.75	0.20 (-0.55, 0.94)	0.28
Cognitive impairment	1.31	0.49	-0.81 (-1.40, -0.23)	0.05
Errors of Commission				
Night time admission (after 8pm)	0.20	0.17	-0.03 (-0.20, 0.14)	0.57
Length of stay ≥ 48 hours	0.17	0.23	0.06 (-0.21, 0.32)	0.88
Age ≥ 80	0.21	0.17	-0.04 (-0.20, 0.12)	0.61
Female sex	0.23	0.13	-0.11 (-0.26, 0.03)	0.20
≥8 Medications on BPMH	0.28	0.12	-0.16 (-0.32, -0.01)	0.02
Prepopulated Med Rec Form	0.18	0.13	-0.06 (-0.39, 0.28)	0.84
Cognitive impairment	0.15	0.18	0.03 (-0.24, 0.29)	0.97

Table 6. Univariate and Multivariate Associations of Characteristics with Medication Discrepancies or Errors of Commission

Characteristics	Unadjusted Odds-Ratio (95% CI)	P-value	Adjusted Odds-Ratio (95% CI)*	P-value
Age ≥ 80 years	1.64 (0.82-3.29)	0.16	1.14 (0.50-2.64)	0.75
Sex (female)	1.52 (0.79-2.93)	0.21	1.52 (0.74-3.12)	0.26
≥ 8 Medications on BPMH	5.00 (2.45-10.17)	< 0.001	5.05 (2.44-10.46)	< 0.001
Cognitive impairment	2.64 (0.82-8.52)	0.10	2.29 (0.55-9.58)	0.26
Medication history not verified	0.84 (0.42-1.70)	0.63	1.10 (0.49-2.44)	0.82

* Adjusted for age, sex, cognitive impairment, ≥ 8 medication on BPMH, and having a medication history not completed