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Prevalence, nature and predictors of prescribing errors in mental health hospitals: a prospective multicentre study

Running title: Prescribing errors in mental health hospitals

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ABSTRACT

Objective: To determine the prevalence, nature and predictors of prescribing errors (PEs) in three mental health hospitals.

Setting: Inpatient units in three National Health Service (NHS) mental health hospitals in the North West of England.

Participants: Trained clinical pharmacists prospectively recorded the number of PEs in newly written or omitted prescription items screened during their routine work on 10 data collection days. A multidisciplinary panel reviewed PE data using established methods to confirm (a) the presence of a PE, (b) the type of PE and (c) whether errors were clinically relevant and likely to cause harm.

Primary outcome measures: Frequency, nature and predictors of PEs.

Results: Of 4427 screened prescription items, 281 were found to have one or more PEs (error rate 6.3% (95% CI 5.6–7.1%)). Multivariate analysis revealed that speciality trainees (OR 1.23 (1.01-1.51)) and staff grade psychiatrists (OR 1.50 (1.05-2.13)) were more likely to make PEs when compared to foundation year one doctors, and that speciality trainees and consultant psychiatrists were twice as likely to make clinically relevant PEs (OR 2.61 (2.11-3.22) and 2.03 (1.66-2.50) respectively). Prescription items screened during prescription chart rewrite (OR 0.52 (0.33-0.82)) or at discharge (OR 0.87 (0.79-0.97)) were less likely to be associated with PEs than items assessed during inpatient stay, although they were more likely to be associated with clinically relevant PEs (OR 2.27 (1.72-2.99) and 4.23 (3.68-4.87) respectively). Prescription items screened at hospital admission were five times more likely (OR 5.39 (2.72-10.69)) to be associated with clinically relevant errors than during patient stay.

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Conclusions: Prescribing errors may be more common in mental health hospitals than previously reported and important targets to minimise these errors have been identified.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Using standardised methods, this study has for the first time prospectively determined the prevalence, nature and predictors of prescribing errors across three mental health hospitals.
- Important potential targets were identified for future research to minimise prescribing errors in this setting.
- The prospective error identification method used and variability in the clinical practice of data collectors may have resulted in an underestimation of the prescribing error rate.

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INTRODUCTION

Medication errors (MEs) and their associated adverse drug events (ADEs) continue to pose significant challenges for healthcare systems worldwide.[1-3] Errors in drug prescribing and administration appear to be the most common MEs.[4-6] In general hospitals prescribing errors (PEs) are estimated to affect between 2% and 15% of medication orders[2,7-9] and are thought to arise from multiple, interacting causes.[8,10-12]

Despite much research activity attempting to understand the frequency, causes and preventive strategies for MEs in general hospital settings, mental health hospitals have been given much less attention.[2,13-15] Published studies of PEs (and/or related ADEs) originate from the United Kingdom (UK),[9,16-23] United States of America (USA)[24-27] and Denmark.[28] In common with reviews of general hospital studies,[2] differences in study methods, settings and definitions preclude synthesis of PE data from relevant studies to gain an overall measure of their impact.[13,15,29]

Not surprisingly, different ME/ADE identification methods influence the outcome rate.[2,14,30] It is accepted that voluntary self-reporting methods such as incident reports grossly underestimate the numbers of MEs that occur when compared to chart review and other detection methods,[30,31] which may make subsequent error rates unrepresentative of the practice environment. A number of PE studies carried out in mental health utilised incident/self-reports[21,23] with others using retrospective medication chart review (with or without incident reports / case note review / direct observation).[16,17,24,25,28] Prospective identification of PEs in UK psychiatry has most commonly involved pharmacists checking prescription charts over different time periods,[9,18-20,22] yielding error rates of 2.2%[18] and 2.4%[22] of prescription items checked (two studies did not provide a denominator[19,20]) and

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31.3% of whole prescriptions checked.[9] Between 42.1% and 65% of PEs are administered to patients before correction by the pharmacist.[18,20,22]

To our knowledge, no studies have utilised prospective screening of only newly written prescription items by pharmacists in psychiatry inpatients to find PEs, as seen in general hospitals.[7,8] This design may reduce the possibility of including errors which have previously been checked and corrected by healthcare staff prior to examination by data collectors.[9,18,20,22] In addition, previous studies in psychiatry have not investigated the differences in PE rates or severity between different prescribers and prescribing stages.[18,20,22] This study aimed to determine the prevalence, nature and predictors of inpatient prescribing errors in UK mental health settings.

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METHOD

Settings

Three mental health NHS Trusts based in the North West of England took part in the study. Each provided a range of inpatient and community services. On weekdays, clinical pharmacists checked inpatient paper prescription charts written on admission, during patient stay, upon chart re-write (charts were rewritten by prescribers once administration records were full), on paper leave prescriptions and on paper discharge prescriptions. Medication lists were reconciled on admission predominantly by pharmacy teams using sources that included the patient, their General Practitioner (GP) records and any medication brought into hospital. One study site used an electronic prescription pro-forma at discharge. Medications were administered by registered nurses or by patients using self-administration. Pharmacist prescription chart review involved confirming the clarity, completeness and clinical appropriateness of each prescribed item, and occurred daily on some wards (e.g. acute adult units) but less frequently on others (e.g. long stay forensic units). Where necessary, patients' medical notes were accessed as part of the pharmacists' assessment of prescribing safety. All inpatient units visited by pharmacists on data collection days were included in the study. Outpatient prescriptions were excluded.

Definitions

The definition of a PE used in this study has been used extensively in prescribing error research:[2,7-9,18,20,22] 'A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription-writing process, there is an unintentional significant reduction in the probability of treatment being timely and effective, or an increase in the risk of harm when compared with generally accepted practice.'[32] This definition was

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accompanied by a list of situations that should be included and excluded as PEs. However, as the mental health environment differs from typical hospital settings upon which this definition was based, we extended its scope to include the following scenarios based on earlier work:[18,20,22] (a) prescribing a drug without first registering a patient with the appropriate monitoring service (e.g. Clozapine Patient Monitoring Service (CPMS)) and (b) prescribing a drug to treat mental health illness without authorisation from a Mental Health Act form (e.g. form T2/T3, Advance Decision).

Data collection

The process of recording inpatient prescribing errors was based on the UK EQUIP study.[7] Clinical pharmacists employed at each site identified PEs for all newly prescribed/written or omitted items as part of their routine clinical practice in this setting during a total of 10 data collection days individually selected between January – April 2013. Omitted items were identified after reconciliation on admission or after comparison with earlier inpatient prescribing documentation and their inclusion in the denominator ensured that pharmacists were able to determine whether items were omitted for a valid clinical reason before recording them as a PE. One data collection day per week was purposively chosen to ensure coverage of all weekdays at least once according to local capacity, with a complete day including the period from 5pm on the previous day until 5pm on the assigned data collection day. On Mondays, this period was extended to include prescriptions written from 5pm the previous Friday throughout the weekend.

Data on the number of newly prescribed or omitted items and the corresponding number of errors were entered onto two standardised forms by pharmacists based on earlier work[7] and underwent piloting at one participating site in December 2012. Newly prescribed orders included once only and when required items. Completion of these forms was for research

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purposes and was outside the pharmacists' normal duties, though time taken on this task was reported to be insignificant during pilot testing. For each prescribing error recorded, pharmacists were asked to record patient information, prescriber grade, stage of patient stay, a potential severity rating (including whether or not the error reached the patient) along with details as to the nature of the PE. Each item checked could be associated with more than one prescribing error.

Pharmacist study co-ordinators based at each site used the same materials to provide training for participating pharmacists which also included question and answer sessions. A standardised guidebook was made available to data collectors for use at any point during the study and co-ordinators made regular contact with data collectors to answer any questions raised.

Error validation

Validation of all recorded PEs was undertaken by a multidisciplinary panel which comprised one mental health clinical pharmacist (RNK), one consultant pharmacist in medicine and medication safety (SDW) and one consultant psychiatrist (JJV). The errors were reviewed and consensus was reached on (a) whether a genuine prescribing error had occurred, (b) type of error and (c) the potential severity of the error using established criteria.[7] PEs that were rated as either potentially clinically significant, serious or life-threatening were considered clinically relevant for patients.

Data analysis

Descriptive statistics were used to analyse frequency of error categories by prescriber grade and prescribing stage, with additional investigations into the nature of PEs identified (route, severity, type, drug class). Error rates were calculated as a percentage to measure the

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prevalence of PEs by dividing the number of newly written or omitted prescription items by the total number of these items screened and multiplying the answer by 100. Error rates were presented with corresponding 95% confidence intervals (CI).

Logistic regression analyses were undertaken to examine (a) predictors of prescribing errors, and (b) predictors of a clinically relevant error (potentially significant, serious or life-threatening) compared to a minor error across different prescribers, prescribing stages, and written vs. electronic prescribing. Analysis of potential error severity also involved comparing errors occurring within the central nervous system class of medicines (which includes all psychotropic medicines) versus all other medication classes,[33] and comparing different subtypes of PEs that occurred. All logistic regression models were adjusted for clustering at study site and results presented as adjusted odds ratios (OR) and 95% Confidence Intervals (CI). All calculations were undertaken using STATA V12®, and $p<0.05$ was used to indicate statistical significance.

Ethics

This study was granted ethical approval by the University of Manchester Research Ethics Committee (12342) and approval was obtained by the Research and Development/Audit Departments from each participating study site.

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RESULTS

During the study period 4427 newly written or omitted prescription items were assessed by study pharmacists across the three study sites. A total of 367 PEs were recorded, 79 of which were excluded during review by the expert panel. Good agreement was observed between panel members when reviewing errors, with the most common reason for exclusion at this stage being minor prescription writing incidents such as trivial spelling mistakes, missing information on prescriptions for use when required (e.g. no indication, no minimum dosage interval) or writing medication names without using capital letters.

After review by the expert panel, 281 newly prescribed or omitted items were found to be affected by 1 or more PEs, giving an error rate of 6.3% (95% CI 5.6-7.1%). Seven prescription items were affected by 2 PEs, giving a total of 288 detected errors. Table 1 displays PE rates by prescriber and stage of prescribing.

Orders prescribed on admission to hospital were associated with the highest PE rate (10.7% (95% CI 8.6-12.7%)) when compared to items prescribed during hospital stay (6.5% (5.3-7.8%)) or at discharge (6.5% (4.3-8.6%)). In contrast, items assessed on leave prescriptions (4.5% (1.9-7.0%)) and those that were re-written by prescribers (3.6% (2.6-4.6%)) had lower PE rates. Speciality trainees (general practitioner or psychiatry) were responsible for the majority of newly written or omitted items (52.8%) and had the highest PE rate (6.8% (5.8-7.8%)). Junior doctors generally had PE rates lower than their senior colleagues (Foundation Year (FY) one 5.1% (2.2-8.0%); FY two 4.9% (3.0-6.7%); staff grade 6.5% (4.2-8.7); consultant 5.8% (3.9-7.7%)).

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Table 1: Summary of prescribing errors by prescriber and prescribing stage

PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
FY1*	Items written/omitted	28	68	46	17	57	0	**216**
	Errors found	1	3	2	0	5	0	**11**
	% error rate (95% confidence intervals)	3.6% (0.0-10.6%)	4.4% (0.0-9.3%)	4.3% (0.0-10.3%)	0% (N/A)	8.8% (1.4-16.2%)	-	**5.1% (2.2-8.0%)**
FY2	Items written/omitted	95	124	179	79	59	0	**536**
	Errors found	5	9	5	5	2	0	**26**
	% error rate (95% confidence intervals)	5.3% (0.7-9.8%)	7.3% (2.7-11.8%)	2.8% (0.4-5.2%)	6.3% (0.9-11.7%)	3.4% (0.0-8.0%)	-	**4.9% (3.0-6.7%)**
Speciality Trainee**	Items written/omitted	582	734	636	114	270	0	**2336**
	Errors found	67	50	26	3	13	0	**159**
	% error rate (95% confidence	11.5%	6.8%	4.1%	2.6%	4.8%	-	**6.8%**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	intervals)	(8.9-14.1%)	(5.0-8.6%)	(2.5-5.6%)	(0.0-5.6%)	(2.3-7.4%)		**(5.8-7.8%)**
Staff Grade Psychiatrist	Items written/omitted	42	148	203	18	38	16	**465**
	Errors found	10	9	5	2	4	0	**30**
	% error rate (95% confidence intervals)	23.8% (10.8-36.9%)	6.1% (2.2-9.9%)	2.5% (0.3-4.6%)	11.1% (0.0-26.1%)	10.5% (0.6-20.4%)	0%	**6.5% (4.2-8.7%)**
Consultant Psychiatrist	Items written/omitted	30	378	124	13	38	3	**586**
	Errors found	3	23	4	0	4	0	**34**
	% error rate (95% confidence intervals)	10.0% (0.0-20.9%)	6.1% (3.7-8.5%)	3.2% (0.1-6.3%)	0%	10.5% (0.6-20.4%)	0%	**5.8% (3.9-7.7%)**
Pharmacist Prescriber	Items written/omitted	0	3	0	0	7	0	**10**
	Errors found	0	0	0	0	0	0	**0**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	% error rate (95% confidence intervals)	-	0%	-	-	0%	-	**0%**
Nurse Prescriber	Items written/omitted	0	12	0	0	0	0	**12**
	Errors found	0	0	0	0	0	0	**0**
	% error rate (95% confidence intervals)	-	0%	-	-	-	-	**0%**
Unknown Prescriber	Items written/omitted	86	63	85	6	26	0	**266**
	Errors found	6	6	4	1	4	0	**21**
	% error rate (95% confidence intervals)	7.0% (1.6-12.4%)	9.5% (2.2-16.8%)	4.7% (0.2-9.2%)	16.7% (0.0-49.3%)	15.4% (1.2-29.5%)	-	**7.9% (4.6-11.1%)**
TOTAL	Items written/omitted	**863**	**1530**	**1273**	**247**	**495**	**19**	**4427**
	Errors found	**92**	**100**	**46**	**11**	**32**	**0**	**281**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	% error rate (95% confidence intervals)	**10.7% (8.6-12.7%)**	**6.5% (5.3-7.8%)**	**3.6% (2.6-4.6%)**	**4.5% (1.9-7.0%)**	**6.5% (4.3-8.6%)**	**0%**	**6.3% (5.6-7.1%)**

* The Foundation Year (FY) programme corresponds to the first two years of medical training for junior doctors after completion of their undergraduate degree, and is similar to internships or residencies in other countries.

** Speciality trainees include General Practitioner trainee (GPST1-3) and psychiatry trainee (CT1-2 and ST4-6) medical grades; FY = Foundation Year

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Nature of PEs identified

The vast majority of identified PEs were associated with the oral route of administration (n=216, 75%) and medicines belonging to the central nervous system class (n=165, 57.3%).

The most common types of PEs were medicines omitted on admission to hospital (n=36, 12.5%), followed by administration times/frequencies that were incorrect or missing (n=33, 11.5%), missing strengths or doses (n=30, 10.4%) and prescribing incorrect drug formulations (n=26, 9.0%). Other common PE subtypes included failing to sign a prescription (n=24), incorrect or missing start dates for prescriptions (n=21) and under-dosing (n=20). Table 2 shows the frequency of all PE subtypes. After review by the multidisciplinary panel, 162 (56.3%) PEs were considered clinically relevant for patients. These findings are summarised in Table 3 and a summary of all potentially serious and life-threatening errors is provided in Table 4.

Half of the 20 potentially serious or life threatening PEs involved central nervous system medicines, with the remaining 10 including cardiovascular system (n=5), endocrine system (n=4, all insulin) and anti-infective therapies (n=1). These error types occurred more commonly in female patients (n=14) and most frequently involved clinical contraindications (n=6), omission on admission (n=5) and missing strengths or doses (n=4); 3 female patients accumulated 11 of these errors, with one affected by 4 clinical contraindications, another with 4 with missing strengths/doses and the final patient with 3 drugs omitted on admission. In contrast, 25% of all potentially serious or life-threatening PEs involved injectable administration routes (subcutaneous route (n=4) or intramuscular (n=1) compared with total of 20/288 (6.9%) overall).

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Table 2: Types of prescribing errors

Type of prescribing error	Subtypes	Frequency (%)
Need for drug	Omission on admission	36 (12.5)
	Omission of discharge/leave prescription	14 (4.9)
	Duplication	13 (4.5)
	Continuation for longer than needed	10 (3.5)
	Omission on rewritten prescription	3 (1.0)
	Drug not prescribed but indicated	1 (0.3)
	No indication	1 (0.3)
	Premature discontinuation	0
Selection of specific drug	Clinical contra-indication	9 (3.1)
	Unintentional prescription of drug	2 (0.7)
	Continuation after adverse drug reaction	0
	Drug interaction	0
	Significant allergy	0
Select dosage regimen	Underdose	20 (6.9)
	Overdose	12 (4.2)
	No maximum dose	5 (1.7)
	Drug interaction not taken into account	1 (0.3)
	Dose / rate mismatch	0
	No dosage alteration after levels out of range	0
	Daily dose divided incorrectly	0
Administration of drug	Administration times/frequencies incorrect/missing	34 (11.8)
	Incorrect formulation	26 (9.0)
	Start date incorrect/missing	21 (7.3)
	Intramuscular instructions incorrect/missing	0
	Incorrect route	0
Provide drug product	Strength/dose missing	30 (10.4)
	No signature	24 (8.3)
	Product/formulation not specified	17 (5.9)

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Type of prescribing error	Subtypes	Frequency (%)
	Prescribed medication not in accordance with Mental Health Act documentation	4 (1.4)
	Route missing	3 (1.0)
	Controlled drug requirements incorrect/missing	1 (0.3)
	Prescription initiated before registration with monitoring service	1 (0.3)

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Table 3: Severity ratings for identified PEs following multidisciplinary review

Potential severity criteria		Examples	Frequency (%)
Not clinically relevant	Minor	Prescription not signed. No start date on prescription.	126 (43.8)
Clinically relevant prescribing errors	Significant	The dose of the drug is too low for a patient with the condition being treated. The wrong route of administration for the condition being treated is ordered e.g. intramuscular depot is prescribed for subcutaneous administration.	142 (49.3)
	Serious	The dose of the drug would result in serum drug levels in the toxic range, e.g. lithium levels 1-2 mmol/L. The drug orders could exacerbate the patient's condition, e.g. drug-drug interaction or drug-disease interaction.	19 (6.6)
	Life-threatening	The drug prescribed has a high potential to cause a life threatening adverse reaction, such as anaphylaxis, in light of the patient's medical history. The dose of a potentially life-saving drug is too low for a patient having the disease being treated.	1 (0.3)

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Table 4: Descriptions of potentially severe and life-threatening prescribing errors

Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
Potentially life threatening	46	Male	Zuclopenthixol Decanoate	300mg weekly	Schizophrenia	Intramuscular	Clinical Contraindication: Patient prescribed this medication after previous prolonged QTc whilst taking olanzapine (no QTc values provided). After olanzapine stopped and zuclopenthixol started, no further ECG taken despite receiving two doses of depot (one of which was an increased dose)
Potentially severe	76	Female	Moxonidine	400 micrograms	Hypertension	Oral	Clinical contraindication: Medication continued on rewritten prescription despite very low blood pressure recorded.
			Bisoprolol	5mg	Hypertension	Oral	As above – same patient
			Lisinopril	10mg	Hypertension	Oral	As above – same patient
			Doxazosin	16mg	Hypertension	Oral	As above – same patient
Potentially severe	26	Female	Quetiapine	450mg	Personality disorder	Oral	Omission on admission: Medicine not prescribed upon inpatient admission
			Diazepam	15mg	Personality disorder	Oral	As above – same patient – doses missed
			Mirtazapine	45mg	Personality disorder	Oral	As above – same patient – doses missed
Potentially severe	48	Female	Novorapid insulin	6 units AM	Diabetes	Subcutaneous	Dose/strength missing: Insulin dose prescribed as 'U' instead of 'Units' which could have been mistaken for 0 i.e. 10 fold error

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Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
			Novorapid insulin	4 units PM	Diabetes	Subcutaneous	As above – same patient
			Novorapid insulin	6 units PM	Diabetes	Subcutaneous	As above – same patient
			Novorapid insulin	4 units PRN	Diabetes	Subcutaneous	
Potentially severe	78	Female	Haloperidol	4mg	Psychotic depression	Oral	Under-dose: Dose prescribed on admission as 500 micrograms twice daily – only 25% of normal dose
Potentially severe	32	Female	Sodium valproate	500mg	Epilepsy	Oral	Omission on admission: Medication not prescribed on admission – dose missed
Potentially severe	32	Male	Enalapril	20mg	Hypertension	Oral	Overdose: Prescribed as 200mg daily on admission – 10 times overdose
Potentially severe	Unknown	Male	Co-trimoxazole	960mg	Pneumocystis pneumonia prophylaxis	Oral	Omission on admission: Failure to prescribe on admission to hospital
Potentially severe	79	Male	Risperidone	3mg	Psychosis	Oral	Duplication: Dose increased from 1mg twice daily to 1.5mg twice

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Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
							daily, but old entry not cancelled.
Potentially severe	44	Male	Citalopram	30mg	Depression	Oral	Omission on discharge/leave prescription: Omitted from discharge prescription
Potentially severe	Unknown	Female	Clozapine	Titration	Psychosis	Oral	Clinical contra-indication: despite efforts to slow pace of clozapine dose escalation (due to tachycardia), dose increased by 50mg daily
Potentially severe	34	Male	Sodium valproate MR	1700mg	Siezures	Oral	Under dose: On admission, missed off 700mg morning dose

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Predictors of PEs

Multivariate logistic regression analysis found that specialist trainee registrars (OR 1.23, 95% CI 1.01-1.51) and staff grade psychiatrists (OR 1.50 (1.05-2.13)) were more likely to make PEs than more junior foundation year 1 doctors (FY1) when controlling for prescribing stage, electronic prescriptions and when clustered for study site (as shown in Table 5).

When compared to items written or omitted during the patients stay, prescribers were less likely to make PEs when medication charts were rewritten or when patients were discharged home (OR 0.52 (0.33-0.82) and 0.87 (0.79-0.97) respectively). Newly written or omitted items on admission showed no differences in risk of PEs (OR 1.81 (0.51-6.37)) nor did items written or omitted for patient leave (OR 0.66 (0.39-1.11)) when compared to those screened during patient stay. No difference in risk of PE was observed when electronic prescriptions were compared to handwritten counterparts (OR 1.30 (0.72-2.35)).

Predictors of clinically relevant PEs

As shown in Table 5, multivariate logistic regression analysis revealed that more experienced medical staff were more likely to make a clinically relevant PE than their junior counterparts (FY1), with speciality trainee registrars (General Practitioner or psychiatry) and consultant psychiatrists being twice as likely to do so (OR 2.61 (2.11-3.22) and 2.03 (1.66-2.50) respectively).

Patient admission and discharge were associated with a significantly increased risk of making a potentially clinically relevant PE when compared with during stay (OR 5.39 (2.72-10.69) and 4.23 (3.68-4.87) respectively), with the process of rewriting prescriptions also at significantly higher risk (OR 2.27 (1.72-2.99)). No difference in risk was observed when leave prescriptions were compared to those written during patient stay.

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When compared against those errors associated with the 'need for drug' PE subcategory, the groups 'select dosage regimen', 'administration of drug' and 'provide drug product' were associated with a lower risk of potentially clinically relevant PEs (OR 0.44 (0.20-0.97), 0.17 (0.09-0.32), 0.04 (0.02-0.12) respectively). The latter two groups in particular were associated with much lower risks; PE types included in these groups were mostly clerical in origin (e.g., missing prescriber signature, see Table 2).

Neither electronic prescriptions (OR 0.92 (0.38-2.22)) nor the central nervous system medication class (OR 0.71 (0.34-1.49)) were associated with an increased likelihood of clinically relevant PEs when compared to minor errors.

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Table 5: Predictors of (a) error likelihood and (b) potential error severity: multivariate logistic models

FACTOR		ODDS OF PRESCRIBING ERROR COMPARED TO NO ERROR		ODDS OF CLINICALLY RELEVANT PRESCRIBING ERROR RATHER THAN A MINOR ERROR*	
		Odds ratio (OR)	95% CI	Odds ratio (OR)	95% CI
Prescriber	**FY1**	Reference		Reference	
	FY2	0.96	0.84 – 1.11	1.83	0.77 – 4.38
	Speciality Trainee **	**1.23**	**1.01 – 1.51**	**2.61**	**2.11 – 3.22**
	Staff Grade Psychiatrist	**1.50**	**1.05 – 2.13**	2.88	0.70 – 11.83
	Consultant Psychiatrist	1.18	0.71 – 1.95	**2.03**	**1.66 – 2.50**
Prescribing stage	**During stay**	Reference		Reference	
	Admission	1.81	0.51 – 6.37	**5.39**	**2.72 – 10.69**
	Re-written item	**0.52**	**0.33 – 0.82**	**2.27**	**1.72 – 2.99**
	Leave	0.66	0.39 – 1.11	2.57	0.74 – 8.95
	Discharge	**0.87**	**0.79 – 0.97**	**4.23**	**3.68 – 4.87**
Electronic item	**No**	Reference		Reference	
	Yes	1.30	0.72 – 2.35	0.92	0.38 – 2.22
Medication class ┼	**All others**	-	-	Reference	
	Central Nervous System	-	-	0.71	0.34 – 1.49
Prescribing error subcategories ***	**Need for drug**	-	-	Reference	
	Selection of specific drug	-	-	2.36	0.23 – 24.48
	Select dosage regimen	-	-	**0.44**	**0.20 – 0.97**
	Administration of drug	-	-	**0.17**	**0.09 – 0.32**
	Provide drug product	-	-	**0.04**	**0.02 – 0.12**
Pseudo R squared values		**0.02**		**0.28**	

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FACTOR		ODDS OF PRESCRIBING ERROR COMPARED TO NO ERROR		ODDS OF CLINICALLY RELEVANT PRESCRIBING ERROR RATHER THAN A MINOR ERROR*	
		Odds ratio (OR)	95% CI	Odds ratio (OR)	95% CI

FY = Foundation Year; * Potentially clinically relevant PEs (either significant, serious of life-threatening) vs. minor errors; ** Speciality trainees include GPST1-3, CT1-2 and ST4-6 medical grades; *** see table 2 for a list of PE subcategories; ┼ = no odds ratio for risk of at least one PE as no denominator data collected for medication classes

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DISCUSSION

Main findings

This is the first study to prospectively identify the prevalence, nature and predictors of inpatient prescribing errors in mental health hospitals for newly written or omitted prescription items, finding an overall rate of 6.3% (95% CI 5.6-7.1%). Most of the PEs identified related to omissions of drugs on admission to or discharge from hospital as well as missing or incorrect prescription requirements (e.g. dose, frequency, signatures, formulations). Over half (56%) of all 288 errors identified were considered to be clinically relevant with the potential to cause patient harm, with 20 (6.9%) being graded as potentially serious or life-threatening. Speciality trainees and staff grade psychiatrists were more likely to make a PE, with speciality trainees and consultants more likely to make a potentially clinically relevant PE. Rewritten and discharge prescription items were significantly less likely to contain a PE than those written during patient stay, but were found to be at higher risk of potentially clinically relevant errors (especially on admission and discharge, where the risk was 5 and 4 times that of during stay, respectively). PE subtypes including prescription writing errors were associated with significantly lower risks of potentially clinically relevant PEs when compared to groups which included omitted and duplicated drugs. Electronic prescribing and the 'central nervous system' drug class (which contains all psychotropic medicines) were found not to be associated with an increased risk of clinically relevant PEs.

Implications of findings

Our overall PE rate of 6.3% is higher than the 2.2%[18] and 2.4%[22] previously reported in UK psychiatric hospitals using prospective medication chart review, and similar to a median rate of 7 per 100 medication orders reported in general hospitals worldwide.[2] However,

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differences in the type of prescription items that were assessed (i.e. we included both newly omitted and written items), the data collection periods (4 days[18] or 5 days[22] versus 10 in this study), severity assessments, study settings and year of publication preclude more direct comparisons.[2,34] Recent UK based general hospital PE investigations using similar methodology as this study reported higher PE rates,[7,8] which may reflect different patient complexities, the working environment, the medicines used (e.g. intravenous medicines are rarely used in psychiatry) and the predominant focus on mental health rather than physical health in psychiatry settings. In contrast, retrospective reviews of case notes / medication charts to identify PEs in psychiatry[25] yields higher error rates of 15% of error opportunities although the denominator and setting of this study was different to ours.

The finding that a sizeable proportion of PEs concerned dosing errors or incomplete prescription items has been noted in other studies of PEs in psychiatry,[18,20,22] and in general hospitals.[2,7-9] However, whilst studies in general hospitals also found that the omission of drugs on admission/discharge/rewritten prescriptions were a leading PE subtype,[2,7-9] previous studies in psychiatry did not[18,20,22] which could relate to how pharmacy services were organised at the time.[13] Omission of drugs on patient transfer may arise due to inadequate communication of drug information[8,35] an issue which may affect mental health settings more acutely given the increasing number of community services creating more care transfer interfaces.[13,36,37] One UK study found that 69% and 43% of hospital admission and discharge medicines were affected by a medication discrepancy, respectively[17] and more recently studies found 50% of hospital admissions (UK based)[38] and 23% of discharges (USA based)[39] were affected, with the most common types being drug omissions. These studies highlight the importance of medicines reconciliation, a practice which is established in UK mental health hospitals[40] and which has shown value in general hospital settings.[41,42]

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Despite the prevalence of drug omission errors during care transfer the patient admission stage was not associated with significantly higher PE rates than during patient stay in this study, with the re-write and discharge stages associated with a significantly lower risks of PEs. However, errors occurring on admission, re-write and discharge were more likely to harm patients (considered as clinically significant errors – potential to cause significant, serious or life-threatening harm), which could reflect the fact that errors could cause immediate deterioration in a patients clinical condition and/or go unnoticed for long periods of time. The clear dangers posed by patient transfer in psychiatry have been recognised nationally in the UK,[37,43] though overall this challenge has received less attention than in general hospitals.[13,15,36] Future research should seek to clarify the frequency, nature and severity of PEs across and between care interfaces in the mental health setting, as well as investigating further the impact of medicines reconciliation.

This study has indicated that more senior speciality trainees and staff grade psychiatrists are at a significantly increased risk of making a PE when compared to their FY one colleagues. This is in contrast to the EQUIP study, which found that junior doctors were more likely to make PEs.[7] The regression analysis also revealed that consultants were at a higher risk of making potentially severe PEs, along with speciality trainees when compared to FY one doctors. Whilst senior doctor prescribing has not been formerly evaluated in psychiatry in relation to PEs, the bulk of prescribing on admission and discharge (where more clinically significant errors occurred) was carried out by speciality trainees, which may explain why this association was found. Consultant prescribing may be more complex and risky than junior doctor prescribing, with negative perceptions towards prescription re-writes from medical staff noted in research from general hospitals also potentially contributing.[11] Future research should investigate in detail the prescribing of more senior clinicians in mental health,

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as previous studies making similar comparisons did not do so in the context of total prescribing burdens using multivariate regression analysis.[18,22]

This study has emphasised the importance of pharmacy teams in the detection and prevention of PEs and associated patient harms in mental health hospitals, as seen elsewhere.[9,18,20,22,25,38] Despite their important contribution to medicines safety and governance there has been less investment in pharmacy services in UK mental health when compared to acute hospitals.[43,44] Given the important contribution of medicines to avoidable harm in hospitals, the input of pharmacy teams in keeping patients safe should not be underestimated.[43,44]

Our analysis did not reveal any difference in the risk of a PE between electronic and hand written prescriptions, though this should be viewed with caution as the number of electronically prescribed items in our analysis was low and the nature of this type of prescribing was limited to discharge prescription templates at one study site (i.e. no commercially available e-prescribing software was used). Although the benefits of electronic prescribing software should not be overlooked[15] further investigation may be required as despite important reductions in some errors the wider effects of electronic prescribing systems on MEs and ADEs is not clear, and in some cases novel PE opportunities may be created.[45]

To our knowledge, there have been no published attempts to determine the causes of PEs in inpatient mental health settings despite growing understanding in general hospitals that these errors involve multiple, interacting antecedents.[8,10-12] Although a number of different interventions designed to reduce PEs have been suggested,[46] future research should focus on determining the causes of PEs in psychiatry using theoretical frameworks such as Reasons Model of Accident Causation,[47] so that the value of these interventions can be measured in this setting.

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Strengths and limitations

Key strengths of this study are that it was larger[18,20] and lasted for a longer duration[18,22] than previous work, used standardised training of data collectors, employed a data collection technique to minimise the risk of double counting or including previously corrected items and sought to compare risk of PEs and clinically relevant errors between prescribing stages and different prescribers.

Combined medication chart and case note review may identify a greater number of PEs,[30] so our PE rate maybe an underestimate of the true burden of these errors in mental health hospitals. Whilst data collectors were trained using standardised materials it is impossible to exclude variation in error detection due to differing capacity, vigilance and/or individual clinical experience of collectors.[9,22] The rate of false positives was minimised by using a multidisciplinary PE review panel, one senior member of which (SDW) had previously evaluated prescribing errors in a much larger study.[7] We did not record separate PE rate data for core medical versus general practitioner speciality trainees or psychotropic versus non-psychotropic medicines, which means that we were unable to compare these different groups.

The fact that unknown prescribers were associated with the highest PE rate (7.9% (4.7–11.1%)) highlights the need to ascertain the identity of prescribers as well as when and where prescribing took place in order to facilitate optimal patient care and rectify mistakes promptly. Prescriber identification becomes an even more critical issue given the more recent emphasis on the importance of feedback to improve prescribing practice and minimise PEs.[7,8,46,48]

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CONCLUSION

Prescribing errors may be more common in mental health hospitals than previously reported, and continue to post a significant challenge to healthcare providers as the majority have the potential to cause patient harm. This study has identified more senior prescribers and care transfer interfaces as potential targets to investigate the burden of these errors in more detail with the aim of formulating remedial approaches. Future work should focus on using theoretical frameworks such as those of human error to investigate the causes of PEs in order to inform the design of interventions aimed at reducing their burden in the psychiatric inpatient setting.

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Competing interests

All the authors have no competing interests to declare. This work has not been posted or published elsewhere in its entirety. An abstract summarising the study will soon be published after oral presentation at the Prescribing and Research in Medicines Management (PRIMM) Annual Scientific Meeting 2014 (2nd May, London, UK).

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Contributor statement

Design of study: all authors. Review of study data (expert panel): RNK, JJV, SDW. Analysis of data: RNK, DMA. Preparation of manuscript: RNK. Critical review of manuscript: all authors. Approval of submitted manuscript (current version): all authors.

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Prevalence, nature and predictors of prescribing errors in mental health hospitals: a prospective multicentre study

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Prevalence, nature and predictors of prescribing errors in mental health hospitals: a prospective multicentre study

Running title: Prescribing errors in mental health hospitals

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ABSTRACT

Objective: To determine the prevalence, nature and predictors of prescribing errors (PEs) in three mental health hospitals.

Setting: Inpatient units in three National Health Service (NHS) mental health hospitals in the North West of England.

Participants: Trained clinical pharmacists prospectively recorded the number of PEs in newly written or omitted prescription items screened during their routine work on 10 data collection days. A multidisciplinary panel reviewed PE data using established methods to confirm (a) the presence of a PE, (b) the type of PE and (c) whether errors were clinically relevant and likely to cause harm.

Primary outcome measures: Frequency, nature and predictors of PEs.

Results: Of 4427 screened prescription items, 281 were found to have one or more PEs (error rate 6.3% (95% CI 5.6–7.1%)). Multivariate analysis revealed that speciality trainees (OR 1.23 (1.01-1.51)) and staff grade psychiatrists (OR 1.50 (1.05-2.13)) were more likely to make PEs when compared to foundation year (FY) one doctors, and that speciality trainees and consultant psychiatrists were twice as likely to make clinically relevant PEs (OR 2.61 (2.11-3.22) and 2.03 (1.66-2.50) respectively) compared to FY one staff. Prescription items screened during prescription chart rewrite (OR 0.52 (0.33-0.82)) or at discharge (OR 0.87 (0.79-0.97)) were less likely to be associated with PEs than items assessed during inpatient stay, although they were more likely to be associated with clinically relevant PEs (OR 2.27 (1.72-2.99) and 4.23 (3.68-4.87) respectively). Prescription items screened at hospital admission were five times more likely (OR 5.39 (2.72-10.69)) to be associated with clinically relevant errors than those screened during patient stay.

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Conclusions: Prescribing errors may be more common in mental health hospitals than previously reported and important targets to minimise these errors have been identified.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Using standardised methods, this study has for the first time prospectively determined the prevalence, nature and predictors of prescribing errors across three mental health hospitals.
- Important potential targets were identified for future research to minimise prescribing errors in this setting.
- Whilst this was a large study, its findings may not be generalizable to inpatient psychiatric care across the NHS.

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INTRODUCTION

Medication errors (MEs) and their associated adverse drug events (ADEs) continue to pose significant challenges for healthcare systems worldwide.[1-3] Errors in drug prescribing and administration appear to be the most common MEs.[4-6] In general hospitals prescribing errors (PEs) are estimated to affect between 2% and 15% of medication orders[2,7-9] and are thought to arise from multiple, interacting causes.[8,10-12]

Despite much research activity attempting to understand the frequency, causes and preventive strategies for MEs in general hospital settings, mental health hospitals have been given much less attention.[2,13-15] Published studies of PEs (and/or related ADEs) originate from the United Kingdom (UK),[9,16-23] United States of America (USA)[24-27] and Denmark.[28] In common with reviews of general hospital studies,[2] differences in study methods, settings and definitions preclude synthesis of PE data from relevant studies to gain an overall measure of their impact.[13,15,29]

Not surprisingly, different ME/ADE identification methods influence the outcome rate.[2,14,30] It is accepted that voluntary self-reporting methods such as incident reports grossly underestimate the numbers of MEs that occur when compared to chart review and other detection methods,[30,31] which may make subsequent error rates unrepresentative of the practice environment. A number of PE studies carried out in mental health utilised incident/self-reports[21,23] with others using retrospective medication chart review (with or without incident reports / case note review / direct observation).[16,17,24,25,28] Prospective identification of PEs in UK psychiatry has most commonly involved pharmacists checking prescription charts over different time periods,[9,18-20,22] yielding error rates of 2.2%[18] and 2.4%[22] of prescription items checked (two studies did not provide a denominator[19,20]) and

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31.3% of whole prescriptions checked.[9] Between 42.1% and 65% of PEs are administered to patients before correction by the pharmacist.[18,20,22]

To our knowledge, no studies have utilised prospective screening of only newly written or omitted prescription items by pharmacists in psychiatry inpatients to find PEs, as seen in general hospitals.[7] This design may reduce the possibility of underestimating PE rates if errors which have previously been checked and corrected by healthcare staff prior to examination by data collectors are included.[9,18,20,22] In addition, previous studies in psychiatry have not investigated the differences in PE rates or severity between different prescribers and prescribing stages.[18,20,22] This study aimed to determine the prevalence, nature and predictors of inpatient prescribing errors in UK mental health settings.

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METHOD

Settings

Three mental health NHS trusts based in the North West of England took part in the study, including more than 50 inpatient wards across more than 10 hospitals and other smaller facilities. Each trust provided a range of inpatient and community services. On weekdays, clinical pharmacists checked inpatient paper prescription charts written on admission, during patient stay, upon chart re-write (charts were rewritten by prescribers once administration records were complete), on paper leave prescriptions (prescriptions used by patients who could leave the ward temporarily, e.g. for a home visit) and on paper discharge prescriptions. Medication lists were reconciled on admission predominantly by pharmacy teams using sources that included the patient, their General Practitioner (GP) records and any medication brought into hospital. One study site used an electronic prescription pro-forma at discharge. Medications were administered by registered nurses or by patients using self-administration. Pharmacist prescription chart review involved confirming the clarity, completeness and clinical appropriateness of each prescribed item, and occurred daily on some wards (e.g. acute adult units) but less frequently on others (e.g. long stay forensic units). Where necessary, patients' medical notes were accessed as part of the pharmacists' assessment of prescribing safety. All inpatient units visited by pharmacists on data collection days were included in the study. Outpatient prescriptions were excluded.

Definitions

The definition of a PE used in this study has been used extensively in prescribing error research:[2,7-9,18,20,22] 'A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription-writing process, there is an unintentional significant

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reduction in the probability of treatment being timely and effective, or an increase in the risk of harm when compared with generally accepted practice.'[32] This definition was accompanied by a list of situations that should be included and excluded as PEs. However, as the mental health environment differs from typical hospital settings upon which this definition was based, we extended its scope to include the following scenarios based on earlier work:[18,20,22] (a) prescribing a drug without first registering a patient with the appropriate monitoring service (e.g. Clozapine Patient Monitoring Service (CPMS)) and (b) prescribing a drug to treat mental health illness without authorisation from a Mental Health Act form (e.g. form T2/T3, Advance Decision).

Data collection

The process of recording inpatient prescribing errors was based on the UK EQUIP study.[7] Twenty nine clinical pharmacists employed across the study sites identified PEs for all newly prescribed/written or omitted items as part of their routine clinical practice in this setting during a total of 10 data collection days individually selected between January – April 2013. Omitted items were identified after reconciliation on admission or after comparison with earlier inpatient prescribing documentation, and their inclusion in the denominator ensured that pharmacists were able to determine whether items were omitted for a valid clinical reason before recording them as a PE. One data collection day per week was purposively chosen to ensure coverage of all weekdays at least once according to local capacity, with a complete day including the period from 5pm on the previous day until 5pm on the assigned data collection day. On Mondays, this period was extended to include prescriptions written from 5pm the previous Friday throughout the weekend.

Data on the number of newly prescribed or omitted items and the corresponding number of errors were entered onto two standardised forms by pharmacists based on earlier work[7] and

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underwent piloting at one participating site in December 2012. Newly prescribed orders included once only and when required items. Completion of these forms was for research purposes and was outside the pharmacists' normal duties, though time taken on this task was reported to be insignificant during pilot testing. For each prescribing error recorded, pharmacists were asked to record patient information, prescriber grade, stage of patient stay, a potential severity rating (including whether or not the error caused actual patient harm) along with details as to the nature of the PE. Each item checked could be associated with more than one prescribing error.

Pharmacist study co-ordinators based at each site used the same materials to provide training for participating pharmacists which also included question and answer sessions. A standardised guidebook (including definitions of PEs and potential severity assessment categories) was made available to data collectors for use at any point during the study and co-ordinators made regular contact with data collectors to answer any questions raised.

Error validation

Validation of all recorded PEs was undertaken by a multidisciplinary panel which comprised one mental health clinical pharmacist (RNK), one consultant pharmacist in medicine and medication safety (SDW) and one consultant psychiatrist (JJV). The errors were reviewed and consensus was reached on (a) whether a genuine prescribing error had occurred, (b) type of error and (c) the potential severity of the error using established criteria.[7] PEs that were rated as either potentially clinically significant, serious or life-threatening were considered clinically relevant for patients.

Data analysis

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Descriptive statistics were used to analyse frequency of error categories by prescriber grade and prescribing stage, with additional investigations into the nature of PEs identified (route, severity, type, drug class). Error rates were calculated as a percentage to measure the prevalence of PEs by dividing the number of newly written or omitted prescription items with at least one PE by the total number of these items screened and multiplying the answer by 100. Error rates were presented with corresponding 95% confidence intervals (CI).

Logistic regression analyses were undertaken to examine (a) predictors of prescribing errors, and (b) predictors of a clinically relevant error (potentially significant, serious or life-threatening) compared to a minor error across different prescribers, prescribing stages, and written vs. electronic discharge pro-forma prescribing. Analysis of potential error severity also involved comparing errors occurring within the central nervous system class of medicines (which includes all psychotropic medicines) versus all other medication classes,[33] and comparing different subtypes of PEs that occurred. All logistic regression models were adjusted for clustering at study site and results presented as adjusted odds ratios (OR) and 95% Confidence Intervals (CI). All calculations were undertaken using STATA V12®, and $p<0.05$ was used to indicate statistical significance.

Ethics

This study was granted ethical approval by the University of Manchester Research Ethics Committee (12342) and approval was obtained by the Research and Development/Audit Departments from each participating study site. Individual patient consent was not required for this service evaluation.

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RESULTS

During the study period 4427 newly written or omitted prescription items were assessed by study pharmacists across the three study sites. A total of 367 PEs were recorded, 79 of which were excluded during review by the expert panel. Good agreement was observed between panel members when reviewing errors, with the most common reason for exclusion at this stage being minor prescription writing incidents such as trivial spelling mistakes, missing information on prescriptions for use when required (e.g. no indication, no minimum dosage interval) or writing medication names without using capital letters.

After review by the expert panel, 281 newly prescribed or omitted items were found to be affected by 1 or more PEs, giving an error rate of 6.3% (95% CI 5.6-7.1%). Seven prescription items were affected by 2 PEs, giving a total of 288 detected errors. Table 1 displays PE rates by prescriber and stage of prescribing.

Orders prescribed on admission to hospital were associated with the highest PE rate (10.7% (95% CI 8.6-12.7%)) when compared to items prescribed during hospital stay (6.5% (5.3-7.8%)) or at discharge (6.5% (4.3-8.6%)). In contrast, items assessed on leave prescriptions (4.5% (1.9-7.0%)) and those that were re-written by prescribers (3.6% (2.6-4.6%)) had lower PE rates. Speciality trainees (general practitioner or psychiatry) were responsible for the majority of newly written or omitted items (52.8%) and had the highest PE rate (6.8% (5.8-7.8%)) after unknown prescribers (7.9% (4.6-11.1%)). Junior FY doctors generally had PE rates lower than their senior colleagues (FY one 5.1% (2.2-8.0%); FY two 4.9% (3.0-6.7%); staff grade 6.5% (4.2-8.7); consultant 5.8% (3.9-7.7%)).

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Table 1: Summary of prescribing errors by prescriber and prescribing stage

PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
FY1*	Items written/omitted	28	68	46	17	57	0	**216**
	Errors found	1	3	2	0	5	0	**11**
	% error rate (95% confidence intervals)	3.6% (0.0-10.6%)	4.4% (0.0-9.3%)	4.3% (0.0-10.3%)	0% (N/A)	8.8% (1.4-16.2%)	-	**5.1% (2.2-8.0%)**
FY2	Items written/omitted	95	124	179	79	59	0	**536**
	Errors found	5	9	5	5	2	0	**26**
	% error rate (95% confidence intervals)	5.3% (0.7-9.8%)	7.3% (2.7-11.8%)	2.8% (0.4-5.2%)	6.3% (0.9-11.7%)	3.4% (0.0-8.0%)	-	**4.9% (3.0-6.7%)**
Speciality Trainee**	Items written/omitted	582	734	636	114	270	0	**2336**
	Errors found	67	50	26	3	13	0	**159**
	% error rate (95% confidence	11.5%	6.8%	4.1%	2.6%	4.8%	-	**6.8%**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	intervals)	(8.9-14.1%)	(5.0-8.6%)	(2.5-5.6%)	(0.0-5.6%)	(2.3-7.4%)		**(5.8-7.8%)**
Staff Grade Psychiatrist	Items written/omitted	42	148	203	18	38	16	**465**
	Errors found	10	9	5	2	4	0	**30**
	% error rate (95% confidence intervals)	23.8% (10.8-36.9%)	6.1% (2.2-9.9%)	2.5% (0.3-4.6%)	11.1% (0.0-26.1%)	10.5% (0.6-20.4%)	0%	**6.5% (4.2-8.7%)**
Consultant Psychiatrist	Items written/omitted	30	378	124	13	38	3	**586**
	Errors found	3	23	4	0	4	0	**34**
	% error rate (95% confidence intervals)	10.0% (0.0-20.9%)	6.1% (3.7-8.5%)	3.2% (0.1-6.3%)	0%	10.5% (0.6-20.4%)	0%	**5.8% (3.9-7.7%)**
Pharmacist Prescriber	Items written/omitted	0	3	0	0	7	0	**10**
	Errors found	0	0	0	0	0	0	**0**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	% error rate (95% confidence intervals)	-	0%	-	-	0%	-	**0%**
Nurse Prescriber	Items written/omitted	0	12	0	0	0	0	**12**
	Errors found	0	0	0	0	0	0	**0**
	% error rate (95% confidence intervals)	-	0%	-	-	-	-	**0%**
Unknown Prescriber	Items written/omitted	86	63	85	6	26	0	**266**
	Errors found	6	6	4	1	4	0	**21**
	% error rate (95% confidence intervals)	7.0% (1.6-12.4%)	9.5% (2.2-16.8%)	4.7% (0.2-9.2%)	16.7% (0.0-49.3%)	15.4% (1.2-29.5%)	-	**7.9% (4.6-11.1%)**
TOTAL	Items written/omitted	**863**	**1530**	**1273**	**247**	**495**	**19**	**4427**
	Errors found	**92**	**100**	**46**	**11**	**32**	**0**	**281**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	% error rate (95% confidence intervals)	**10.7% (8.6-12.7%)**	**6.5% (5.3-7.8%)**	**3.6% (2.6-4.6%)**	**4.5% (1.9-7.0%)**	**6.5% (4.3-8.6%)**	**0%**	**6.3% (5.6-7.1%)**

* The Foundation Year (FY) programme corresponds to the first two years of medical training for junior doctors after completion of their undergraduate degree, and is similar to internships or residencies in other countries.

** Speciality trainees include General Practitioner trainee (GPST1-3) and psychiatry trainee (CT1-2 and ST4-6) medical grades; FY = Foundation Year

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Nature of PEs identified

The vast majority of identified PEs were associated with the oral route of administration (n=216, 75%) and medicines belonging to the central nervous system class (n=165, 57.3%).

The most common types of PEs were medicines omitted on admission to hospital (n=36, 12.5%), followed by administration times/frequencies that were incorrect or missing (n=33, 11.5%), missing strengths or doses (n=30, 10.4%) and prescribing incorrect drug formulations (n=26, 9.0%). Other common PE subtypes included failing to sign a prescription (n=24), incorrect or missing start dates for prescriptions (n=21) and under-dosing (n=20). Table 2 shows the frequency of all PE subtypes. After review by the multidisciplinary panel, 162 (56.3%) PEs were considered clinically relevant for patients. No PEs were reported by pharmacists to cause actual patient harm. These findings are summarised in Table 3 and a summary of all potentially serious and life-threatening errors is provided in Table 4.

Half of the 20 potentially serious or life threatening PEs involved central nervous system medicines, with the remaining 10 including cardiovascular system (n=5), endocrine system (n=4, all insulin) and anti-infective therapies (n=1). These error types occurred more commonly in female patients (n=14) and most frequently involved clinical contraindications (n=6), omission on admission (n=5) and missing strengths or doses (n=4); 3 female patients accumulated 11 of these errors, with one affected by 4 clinical contraindications, another with 4 with missing strengths/doses and the final patient with 3 drugs omitted on admission. In contrast, 25% of all potentially serious or life-threatening PEs involved injectable administration routes (subcutaneous route (n=4) or intramuscular (n=1) compared with total of 20/288 (6.9%) overall).

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Table 2: Types of prescribing errors

Type of prescribing error	Subtypes	Frequency (%)
Need for drug	Omission on admission	36 (12.5)
	Omission of discharge/leave prescription	14 (4.9)
	Duplication	13 (4.5)
	Continuation for longer than needed	10 (3.5)
	Omission on rewritten prescription	3 (1.0)
	Drug not prescribed but indicated	1 (0.3)
	No indication	1 (0.3)
	Premature discontinuation	0
Selection of specific drug	Clinical contra-indication	9 (3.1)
	Unintentional prescription of drug	2 (0.7)
	Continuation after adverse drug reaction	0
	Drug interaction	0
	Significant allergy	0
Select dosage regimen	Underdose	20 (6.9)
	Overdose	12 (4.2)
	No maximum dose	5 (1.7)
	Drug interaction not taken into account	1 (0.3)
	Dose / rate mismatch	0
	No dosage alteration after levels out of range	0
	Daily dose divided incorrectly	0
Administration of drug	Administration times/frequencies incorrect/missing	34 (11.8)
	Incorrect formulation	26 (9.0)
	Start date incorrect/missing	21 (7.3)
	Intramuscular instructions incorrect/missing	0
	Incorrect route	0
Provide drug product	Strength/dose missing	30 (10.4)
	No signature	24 (8.3)
	Product/formulation not specified	17 (5.9)

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Type of prescribing error	Subtypes	Frequency (%)
	Prescribed medication not in accordance with Mental Health Act documentation	4 (1.4)
	Route missing	3 (1.0)
	Controlled drug requirements incorrect/missing	1 (0.3)
	Prescription initiated before registration with monitoring service	1 (0.3)

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Table 3: Severity ratings for identified PEs following multidisciplinary review

Potential severity criteria		Examples	Frequency (%)
Not clinically relevant	Minor	Prescription not signed. No start date on prescription.	126 (43.8)
Clinically relevant prescribing errors	Significant	The dose of the drug is too low for a patient with the condition being treated. The wrong route of administration for the condition being treated is ordered e.g. intramuscular depot is prescribed for subcutaneous administration.	142 (49.3)
	Serious	The dose of the drug would result in serum drug levels in the toxic range, e.g. lithium levels 1-2 mmol/L. The drug orders could exacerbate the patient's condition, e.g. drug-drug interaction or drug-disease interaction.	19 (6.6)
	Life-threatening	The drug prescribed has a high potential to cause a life threatening adverse reaction, such as anaphylaxis, in light of the patient's medical history. The dose of a potentially life-saving drug is too low for a patient having the disease being treated.	1 (0.3)

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Table 4: Descriptions of potentially serious and life-threatening prescribing errors

Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
Potentially life threatening	46	Male	Zuclopenthixol Decanoate	300mg weekly	Schizophrenia	Intramuscular	Clinical Contraindication: Patient prescribed this medication after previous prolonged QTc whilst taking olanzapine (no QTc values provided). After olanzapine stopped and zuclopenthixol started, no further ECG taken despite receiving two doses of depot (one of which was an increased dose)
Potentially serious	76	Female	Moxonidine	400 micrograms	Hypertension	Oral	Clinical contraindication: Medication continued on rewritten prescription despite very low blood pressure recorded.
			Bisoprolol	5mg	Hypertension	Oral	As above – same patient
			Lisinopril	10mg	Hypertension	Oral	As above – same patient
			Doxazosin	16mg	Hypertension	Oral	As above – same patient
Potentially serious	26	Female	Quetiapine	450mg	Personality disorder	Oral	Omission on admission: Medicine not prescribed upon inpatient admission
			Diazepam	15mg	Personality disorder	Oral	As above – same patient – doses missed
			Mirtazapine	45mg	Personality disorder	Oral	As above – same patient – doses missed
Potentially serious	48	Female	Novorapid insulin	6 units AM	Diabetes	Subcutaneous	Dose/strength missing: Insulin dose prescribed as 'U' instead of 'Units' which could have been mistaken for 0 i.e. 10 fold error

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Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
			Novorapid insulin	4 units PM	Diabetes	Subcutaneous	As above – same patient
			Novorapid insulin	6 units PM	Diabetes	Subcutaneous	As above – same patient
			Novorapid insulin	4 units PRN	Diabetes	Subcutaneous	
Potentially serious	78	Female	Haloperidol	4mg	Psychotic depression	Oral	Under-dose: Dose prescribed on admission as 500 micrograms twice daily – only 25% of normal dose
Potentially serious	32	Female	Sodium valproate	500mg	Epilepsy	Oral	Omission on admission: Medication not prescribed on admission – dose missed
Potentially serious	32	Male	Enalapril	20mg	Hypertension	Oral	Overdose: Prescribed as 200mg daily on admission – 10 times overdose
Potentially serious	Unknown	Male	Co-trimoxazole	960mg	Pneumocystis pneumonia prophylaxis	Oral	Omission on admission: Failure to prescribe on admission to hospital
Potentially serious	79	Male	Risperidone	3mg	Psychosis	Oral	Duplication: Dose increased from 1mg twice daily to 1.5mg twice

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Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
							daily, but old entry not cancelled.
Potentially serious	44	Male	Citalopram	30mg	Depression	Oral	Omission on discharge/leave prescription: Omitted from discharge prescription
Potentially serious	Unknown	Female	Clozapine	Titration	Psychosis	Oral	Clinical contra-indication: despite efforts to slow pace of clozapine dose escalation (due to tachycardia), dose increased by 50mg daily
Potentially serious	34	Male	Sodium valproate MR	1700mg	Siezures	Oral	Under dose: On admission, missed off 700mg morning dose

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Predictors of PEs

Multivariate logistic regression analysis found that specialist trainee registrars (OR 1.23, 95% CI 1.01-1.51) and staff grade psychiatrists (OR 1.50 (1.05-2.13)) were more likely to make PEs than more junior foundation year 1 doctors (FY1) when controlling for prescribing stage, electronic discharge prescriptions and when clustered for study site (as shown in Table 5).

When compared to items written or omitted during the patients stay, prescribers were less likely to make PEs when medication charts were rewritten or when patients were discharged home (OR 0.52 (0.33-0.82) and 0.87 (0.79-0.97) respectively). Newly written or omitted items on admission showed no differences in risk of PEs (OR 1.81 (0.51-6.37)) nor did items written or omitted for patient leave (OR 0.66 (0.39-1.11)) when compared to those screened during patient stay. No difference in risk of PE was observed when discharge prescriptions written on a standard electronic pro-forma were compared to handwritten counterparts (OR 1.30 (0.72-2.35)).

Predictors of clinically relevant PEs

As shown in Table 5, multivariate logistic regression analysis revealed that more experienced medical staff were more likely to make a clinically relevant PE than their junior counterparts (FY1), with speciality trainee registrars (General Practitioner or psychiatry) and consultant psychiatrists being twice as likely to do so (OR 2.61 (2.11-3.22) and 2.03 (1.66-2.50) respectively).

Patient admission and discharge were associated with a significantly increased risk of making a potentially clinically relevant PE when compared with during stay (OR 5.39 (2.72-10.69) and 4.23 (3.68-4.87) respectively), with the process of rewriting prescriptions also at

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significantly higher risk (OR 2.27 (1.72-2.99)). No difference in risk was observed when leave prescriptions were compared to those written during patient stay.

When compared against those errors associated with the 'need for drug' PE subcategory, the groups 'select dosage regimen', 'administration of drug' and 'provide drug product' were associated with a lower risk of potentially clinically relevant PEs (OR 0.44 (0.20-0.97), 0.17 (0.09-0.32), 0.04 (0.02-0.12) respectively). The latter two groups in particular were associated with much lower risks; PE types included in these groups were mostly clerical in origin (e.g., missing prescriber signature, see Table 2).

Neither prescriptions written on a standard electronic pro-forma (OR 0.92 (0.38-2.22)) nor the central nervous system medication class (OR 0.71 (0.34-1.49)) were associated with an increased likelihood of clinically relevant PEs when compared to minor errors.

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Table 5: Predictors of (a) error likelihood and (b) potential error severity: multivariate logistic models

FACTOR		ODDS OF PRESCRIBING ERROR COMPARED TO NO ERROR		ODDS OF CLINICALLY RELEVANT PRESCRIBING ERROR RATHER THAN A MINOR ERROR*	
		Odds ratio (OR)	95% CI	Odds ratio (OR)	95% CI
Prescriber	**FY1**	Reference		Reference	
	FY2	0.96	0.84 – 1.11	1.83	0.77 – 4.38
	Speciality Trainee **	**1.23**	**1.01 – 1.51**	**2.61**	**2.11 – 3.22**
	Staff Grade Psychiatrist	**1.50**	**1.05 – 2.13**	2.88	0.70 – 11.83
	Consultant Psychiatrist	1.18	0.71 – 1.95	**2.03**	**1.66 – 2.50**
Prescribing stage	**During stay**	Reference		Reference	
	Admission	1.81	0.51 – 6.37	**5.39**	**2.72 – 10.69**
	Re-written item	**0.52**	**0.33 – 0.82**	**2.27**	**1.72 – 2.99**
	Leave	0.66	0.39 – 1.11	2.57	0.74 – 8.95
	Discharge	**0.87**	**0.79 – 0.97**	**4.23**	**3.68 – 4.87**
Electronic discharge pro-forma item	**No**	Reference		Reference	
	Yes	1.30	0.72 – 2.35	0.92	0.38 – 2.22
Medication class ┼	**All others**	-	-	Reference	
	Central Nervous System	-	-	0.71	0.34 – 1.49
Prescribing error subcategories ***	**Need for drug**	-	-	Reference	
	Selection of specific drug	-	-	2.36	0.23 – 24.48
	Select dosage regimen	**-**	**-**	**0.44**	**0.20 – 0.97**
	Administration of drug	**-**	**-**	**0.17**	**0.09 – 0.32**
	Provide drug product	**-**	**-**	**0.04**	**0.02 – 0.12**
Pseudo R squared values		**0.02**		**0.28**	

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FACTOR		ODDS OF PRESCRIBING ERROR COMPARED TO NO ERROR		ODDS OF CLINICALLY RELEVANT PRESCRIBING ERROR RATHER THAN A MINOR ERROR*	
		Odds ratio (OR)	95% CI	Odds ratio (OR)	95% CI

FY = Foundation Year; * Potentially clinically relevant PEs (either significant, serious of life-threatening) vs. minor errors; ** Speciality trainees include GPST1-3, CT1-2 and ST4-6 medical grades; *** see table 2 for a list of PE subcategories; ┼ = no odds ratio for risk of at least one PE as no denominator data collected for medication classes

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DISCUSSION

Main findings

This is the first study to prospectively identify the prevalence, nature and predictors of inpatient prescribing errors in mental health hospitals for only newly written or omitted prescription items, finding an overall rate of 6.3% (95% CI 5.6-7.1%). Most of the PEs identified related to omissions of drugs on admission to or discharge from hospital as well as missing or incorrect prescription requirements (e.g. dose, frequency, signatures, formulations). Over half (56%) of all 288 errors identified were considered to be clinically relevant with the potential to cause patient harm, with 20 (6.9%) being graded as potentially serious or life-threatening. Speciality trainees and staff grade psychiatrists were more likely to make a PE, with speciality trainees and consultants more likely to make a potentially clinically relevant PE. Rewritten and discharge prescription items were significantly less likely to contain a PE than those written during patient stay, but were found to be at higher risk of potentially clinically relevant errors (especially on admission and discharge, where the risk was 5 and 4 times that of during stay, respectively). PE subtypes including prescription writing errors were associated with significantly lower risks of potentially clinically relevant PEs when compared to groups which included omitted and duplicated drugs. Electronic prescribing at discharge using a template and the 'central nervous system' drug class (which contains all psychotropic medicines) were found not to be associated with an increased risk of clinically relevant PEs.

Implications of findings

Our overall PE rate of 6.3% is higher than the 2.2%[18] and 2.4%[22] previously reported in UK psychiatric hospitals using prospective medication chart review, and similar to a median

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rate of 7 per 100 medication orders reported in general hospitals worldwide.[2] However, differences in the type of prescription items that were assessed (i.e. we included only newly omitted and written items), the data collection periods (4 days[18] or 5 days[22] versus 10 in this study), severity assessments, study settings and year of publication preclude more direct comparisons.[2,34] Recent UK based general hospital PE investigations using similar methodology as this study reported higher PE rates,[7,8] which may reflect different patient complexities, the working environment, the medicines used (e.g. intravenous medicines are rarely used in psychiatry) and the predominant focus on mental health rather than physical health in psychiatry settings. In contrast, retrospective reviews of case notes / medication charts to identify PEs in psychiatry[25] yields higher error rates of 15% of error opportunities although the denominator and setting of this study was different to ours.

The finding that a sizeable proportion of PEs concerned dosing errors or incomplete prescription items has been noted in other studies of PEs in psychiatry,[18,20,22] and in general hospitals.[2,7-9] However, whilst studies in general hospitals also found that the omission of drugs on admission/discharge/rewritten prescriptions were a leading PE subtype,[2,7-9] previous studies in psychiatry did not.[18,20,22] Omission of drugs on patient transfer may arise due to inadequate communication of drug information[8,35] an issue which may affect mental health settings more acutely given the increasing number of community services creating more care transfer interfaces.[13,36,37] One UK study found that 69% and 43% of hospital admission and post-discharge medicines were affected by a medication discrepancy, respectively[17] and more recently studies found 56.2% of hospital admissions (UK based)[38] and 23.3% of discharges (USA based)[39] were affected, with the most common types being drug omissions. These studies highlight the importance of medicines reconciliation, a practice

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which is established in UK mental health hospitals[40] and which has shown value across hospital settings.[38,40-42]

Despite the prevalence of drug omission errors during care transfer the patient admission stage was not associated with significantly higher PE rates than during patient stay in this study, with the re-write and discharge stages associated with a significantly lower risks of PEs. However, errors occurring on admission, re-write and discharge were more likely to harm patients (considered as clinically significant errors – potential to cause significant, serious or life-threatening harm), which could reflect the fact that errors could cause immediate deterioration in a patients clinical condition and/or go unnoticed for long periods of time. The clear dangers posed by patient transfer in psychiatry have been recognised nationally in the UK,[37,43] though overall this challenge has received less attention than in general hospitals.[13,15,36] Future research should seek to clarify the frequency, nature and severity of PEs across and between care interfaces in the mental health setting, as well as investigating further the impact of medicines reconciliation.

This study has indicated that more senior speciality trainees and staff grade psychiatrists are at a significantly increased risk of making a PE when compared to their FY one colleagues. This is in contrast to the EQUIP study, which found that junior doctors were more likely to make PEs.[7] The regression analysis also revealed that consultants were at a higher risk of making potentially clinically relevant PEs, along with speciality trainees when compared to FY one doctors. Whilst senior doctor prescribing has not been formerly evaluated in psychiatry in relation to PEs, the bulk of prescribing on admission and discharge (where more clinically significant errors occurred) was carried out by speciality trainees, which may explain why this association was found. Consultant prescribing may be more complex and risky than junior doctor prescribing, with negative perceptions towards prescription re-writes

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from medical staff noted in research from general hospitals also potentially contributing.[11] Future research should investigate in detail the prescribing of more senior clinicians in mental health, as previous studies making similar comparisons did not do so in the context of total prescribing burdens using multivariate regression analysis.[18,22]

This study has emphasised the importance of pharmacy teams in the detection and prevention of PEs and associated patient harms in mental health hospitals, as seen elsewhere.[9,18,20,22,25,38] Given the important contribution of medicines to avoidable harm in hospitals, the input of pharmacy teams in keeping patients safe should not be underestimated.[43]

Our analysis did not reveal any difference in the risk of a PE between electronic and hand written prescriptions, though this should be viewed with caution as the number of electronically prescribed items in our analysis was low and the nature of this type of prescribing was limited to discharge prescription templates at one study site (i.e. no commercially available e-prescribing software was used). Although the benefits of electronic prescribing software should not be overlooked[15] further investigation may be required as despite important reductions in some errors the wider effects of electronic prescribing systems on MEs and ADEs is not clear, and in some cases novel PE opportunities may be created.[44]

To our knowledge, there have been no published attempts to determine the causes of PEs in inpatient mental health settings despite growing understanding in general hospitals that these errors involve multiple, interacting antecedents.[7,8,10-12] Although a number of different interventions designed to reduce PEs have been suggested,[45] future research should focus on determining the causes of PEs in psychiatry using theoretical frameworks such as Reason's Model of Accident Causation[46] as recommended previously.[13,15,47] Reason's model has been used frequently in general hospitals for this purpose,[7,10-12] and such investigations

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would facilitate measurement of the value of remedial interventions in the psychiatry setting. As a large proportion of care for mental health patients takes place in the community, future studies of PEs could also be carried out in this setting.[13,36]

Strengths and limitations

Key strengths of this study are that it used standardised training of data collectors, sought to compare risk of PEs and clinically relevant errors between prescribers and prescribing stages, and collected data on only newly written or omitted items over a range of data collection days so that items were counted only once and the risk of including previously corrected items was minimised.

Although this study was conducted across three sites over a large geographical area, generalizability may be limited when compared to earlier work.[22] Combined medication chart and case note review may identify a greater number of PEs,[30] so our PE rate maybe an underestimate of the true burden of these errors in mental health hospitals. Whilst data collectors were trained using standardised materials it is impossible to exclude variation in error detection due to differing workloads,[48] vigilance and/or individual clinical experience of collectors.[9,22] The rate of false positives was minimised by using a multidisciplinary PE review panel, one senior member of which (SDW) had previously evaluated prescribing errors in a much larger study.[7] We did not record separate PE rate data for core medical versus general practitioner speciality trainees or psychotropic versus non-psychotropic medicines, which means that we were unable to compare these different groups.

The fact that unknown prescribers were associated with the highest PE rate (7.9% (4.7–11.1%)) highlights the need to ascertain the identity of prescribers as well as when and where prescribing took place in order to facilitate optimal patient care and rectify mistakes promptly.

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Prescriber identification becomes an even more critical issue given the more recent emphasis on the importance of feedback to improve prescribing practice and minimise PEs.[7,8,45,49]

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CONCLUSION

Prescribing errors may be more common in mental health hospitals than previously reported, and continue to post a significant challenge to healthcare providers as the majority have the potential to cause patient harm. This study has identified more senior prescribers and care transfer interfaces as potential targets to investigate the burden of these errors in more detail with the aim of formulating remedial approaches. Future work should focus on using theoretical frameworks such as those of human error to investigate the causes of PEs in order to inform the design of interventions aimed at reducing their burden in the psychiatric inpatient setting.

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Competing interests

All the authors have no competing interests to declare. This work has not been posted or published elsewhere in its entirety. An abstract summarising the study will soon be published after oral presentation at the Prescribing and Research in Medicines Management (PRIMM) Annual Scientific Meeting 2014 (2nd May, London, UK).

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Contributor statement

Design of study: all authors. Review of study data (expert panel): RNK, JJV, SDW. Analysis of data: RNK, DMA. Preparation of manuscript: RNK. Critical review of manuscript: all authors. Approval of submitted manuscript (current version): all authors.

Data sharing

No additional data available.

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Prevalence, nature and predictors of prescribing errors in mental health hospitals: a prospective multicentre study

Running title: Prescribing errors in mental health hospitals

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ABSTRACT

Objective: To determine the prevalence, nature and predictors of prescribing errors (PEs) in three mental health hospitals.

Setting: Inpatient units in three National Health Service (NHS) mental health hospitals in the North West of England.

Participants: Trained clinical pharmacists prospectively recorded the number of PEs in newly written or omitted prescription items screened during their routine work on 10 data collection days. A multidisciplinary panel reviewed PE data using established methods to confirm (a) the presence of a PE, (b) the type of PE and (c) whether errors were clinically relevant and likely to cause harm.

Primary outcome measures: Frequency, nature and predictors of PEs.

Results: Of 4427 screened prescription items, 281 were found to have one or more PEs (error rate 6.3% (95% CI 5.6–7.1%)). Multivariate analysis revealed that speciality trainees (OR 1.23 (1.01-1.51)) and staff grade psychiatrists (OR 1.50 (1.05-2.13)) were more likely to make PEs when compared to foundation year (FY) one doctors, and that speciality trainees and consultant psychiatrists were twice as likely to make clinically relevant PEs (OR 2.61 (2.11-3.22) and 2.03 (1.66-2.50) respectively) compared to FY one staff. Prescription items screened during prescription chart rewrite (OR 0.52 (0.33-0.82)) or at discharge (OR 0.87 (0.79-0.97)) were less likely to be associated with PEs than items assessed during inpatient stay, although they were more likely to be associated with clinically relevant PEs (OR 2.27 (1.72-2.99) and 4.23 (3.68-4.87) respectively). Prescription items screened at hospital admission were five times more likely (OR 5.39 (2.72-10.69)) to be associated with clinically relevant errors than those screened during patient stay.

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Conclusions: Prescribing errors may be more common in mental health hospitals than previously reported and important targets to minimise these errors have been identified.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Using standardised methods, this study has for the first time prospectively determined the prevalence, nature and predictors of prescribing errors across three mental health hospitals.
- Important potential targets were identified for future research to minimise prescribing errors in this setting.
- Whilst this was a large study, its findings may not be generalizable to inpatient psychiatric care across the NHS.

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INTRODUCTION

Medication errors (MEs) and their associated adverse drug events (ADEs) continue to pose significant challenges for healthcare systems worldwide.[1-3] Errors in drug prescribing and administration appear to be the most common MEs.[4-6] In general hospitals prescribing errors (PEs) are estimated to affect between 2% and 15% of medication orders[2,7-9] and are thought to arise from multiple, interacting causes.[8,10-12]

Despite much research activity attempting to understand the frequency, causes and preventive strategies for MEs in general hospital settings, mental health hospitals have been given much less attention.[2,13-15] Published studies of PEs (and/or related ADEs) originate from the United Kingdom (UK),[9,16-23] United States of America (USA)[24-27] and Denmark.[28] In common with reviews of general hospital studies,[2] differences in study methods, settings and definitions preclude synthesis of PE data from relevant studies to gain an overall measure of their impact.[13,15,29]

Not surprisingly, different ME/ADE identification methods influence the outcome rate.[2,14,30] It is accepted that voluntary self-reporting methods such as incident reports grossly underestimate the numbers of MEs that occur when compared to chart review and other detection methods,[30,31] which may make subsequent error rates unrepresentative of the practice environment. A number of PE studies carried out in mental health utilised incident/self-reports[21,23] with others using retrospective medication chart review (with or without incident reports / case note review / direct observation).[16,17,24,25,28] Prospective identification of PEs in UK psychiatry has most commonly involved pharmacists checking prescription charts over different time periods,[9,18-20,22] yielding error rates of 2.2%[18] and 2.4%[22] of prescription items checked (two studies did not provide a denominator[19,20]) and

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31.3% of whole prescriptions checked.[9] Between 42.1% and 65% of PEs are administered to patients before correction by the pharmacist.[18,20,22]

To our knowledge, no studies have utilised prospective screening of only newly written or omitted prescription items by pharmacists in psychiatry inpatients to find PEs, as seen in general hospitals.[7,8] This design may reduce the possibility of underestimating PE rates if errors which have previously been checked and corrected by healthcare staff prior to examination by data collectors are included.[9,18,20,22] In addition, previous studies in psychiatry have not investigated the differences in PE rates or severity between different prescribers and prescribing stages.[18,20,22] This study aimed to determine the prevalence, nature and predictors of inpatient prescribing errors in UK mental health settings.

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METHOD

Settings

Three mental health NHS trusts based in the North West of England took part in the study, including more than 50 inpatient wards across more than 10 hospitals and other smaller facilities. Each trust provided a range of inpatient and community services. On weekdays, clinical pharmacists checked inpatient paper prescription charts written on admission, during patient stay, upon chart re-write (charts were rewritten by prescribers once administration records were complete), on paper leave prescriptions (prescriptions used by patients who could leave the ward temporarily, e.g. for a home visit) and on paper discharge prescriptions. Medication lists were reconciled on admission predominantly by pharmacy teams using sources that included the patient, their General Practitioner (GP) records and any medication brought into hospital. One study site used an electronic prescription pro-forma at discharge. Medications were administered by registered nurses or by patients using self-administration. Pharmacist prescription chart review involved confirming the clarity, completeness and clinical appropriateness of each prescribed item, and occurred daily on some wards (e.g. acute adult units) but less frequently on others (e.g. long stay forensic units). Where necessary, patients' medical notes were accessed as part of the pharmacists' assessment of prescribing safety. All inpatient units visited by pharmacists on data collection days were included in the study. Outpatient prescriptions were excluded.

Definitions

The definition of a PE used in this study has been used extensively in prescribing error research:[2,7-9,18,20,22] 'A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription-writing process, there is an unintentional significant

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reduction in the probability of treatment being timely and effective, or an increase in the risk of harm when compared with generally accepted practice.'[32] This definition was accompanied by a list of situations that should be included and excluded as PEs. However, as the mental health environment differs from typical hospital settings upon which this definition was based, we extended its scope to include the following scenarios based on earlier work:[18,20,22] (a) prescribing a drug without first registering a patient with the appropriate monitoring service (e.g. Clozapine Patient Monitoring Service (CPMS)) and (b) prescribing a drug to treat mental health illness without authorisation from a Mental Health Act form (e.g. form T2/T3, Advance Decision).

Data collection

The process of recording inpatient prescribing errors was based on the UK EQUIP study.[7] Twenty nine clinical pharmacists employed across the study sites identified PEs for all newly prescribed/written or omitted items as part of their routine clinical practice in this setting during a total of 10 data collection days individually selected between January – April 2013. Omitted items were identified after reconciliation on admission or after comparison with earlier inpatient prescribing documentation, and their inclusion in the denominator ensured that pharmacists were able to determine whether items were omitted for a valid clinical reason before recording them as a PE. One data collection day per week was purposively chosen to ensure coverage of all weekdays at least once according to local capacity, with a complete day including the period from 5pm on the previous day until 5pm on the assigned data collection day. On Mondays, this period was extended to include prescriptions written from 5pm the previous Friday throughout the weekend.

Data on the number of newly prescribed or omitted items and the corresponding number of errors were entered onto two standardised forms by pharmacists based on earlier work[7] and

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underwent piloting at one participating site in December 2012. Newly prescribed orders included once only and when required items. Completion of these forms was for research purposes and was outside the pharmacists' normal duties, though time taken on this task was reported to be insignificant during pilot testing. For each prescribing error recorded, pharmacists were asked to record patient information, prescriber grade, stage of patient stay, a potential severity rating (including whether or not the error caused actual patient harm) along with details as to the nature of the PE. Each item checked could be associated with more than one prescribing error.

Pharmacist study co-ordinators based at each site used the same materials to provide training for participating pharmacists which also included question and answer sessions. A standardised guidebook (including definitions of PEs and potential severity assessment categories) was made available to data collectors for use at any point during the study and co-ordinators made regular contact with data collectors to answer any questions raised.

Error validation

Validation of all recorded PEs was undertaken by a multidisciplinary panel which comprised one mental health clinical pharmacist (RNK), one consultant pharmacist in medicine and medication safety (SDW) and one consultant psychiatrist (JJV). The errors were reviewed and consensus was reached on (a) whether a genuine prescribing error had occurred, (b) type of error and (c) the potential severity of the error using established criteria.[7] PEs that were rated as either potentially clinically significant, serious or life-threatening were considered clinically relevant for patients.

Data analysis

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Descriptive statistics were used to analyse frequency of error categories by prescriber grade and prescribing stage, with additional investigations into the nature of PEs identified (route, severity, type, drug class). Error rates were calculated as a percentage to measure the prevalence of PEs by dividing the number of newly written or omitted prescription items with at least one PE by the total number of these items screened and multiplying the answer by 100. Error rates were presented with corresponding 95% confidence intervals (CI).

Logistic regression analyses were undertaken to examine (a) predictors of prescribing errors, and (b) predictors of a clinically relevant error (potentially significant, serious or life-threatening) compared to a minor error across different prescribers, prescribing stages, and written vs. electronic discharge pro-forma prescribing. Analysis of potential error severity also involved comparing errors occurring within the central nervous system class of medicines (which includes all psychotropic medicines) versus all other medication classes,[33] and comparing different subtypes of PEs that occurred. All logistic regression models were adjusted for clustering at study site and results presented as adjusted odds ratios (OR) and 95% Confidence Intervals (CI). All calculations were undertaken using STATA V12®, and $p<0.05$ was used to indicate statistical significance.

Ethics

This study was granted ethical approval by the University of Manchester Research Ethics Committee (12342) and approval was obtained by the Research and Development/Audit Departments from each participating study site. Individual patient consent was not required for this service evaluation.

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RESULTS

During the study period 4427 newly written or omitted prescription items were assessed by study pharmacists across the three study sites. A total of 367 PEs were recorded, 79 of which were excluded during review by the expert panel. Good agreement was observed between panel members when reviewing errors, with the most common reason for exclusion at this stage being minor prescription writing incidents such as trivial spelling mistakes, missing information on prescriptions for use when required (e.g. no indication, no minimum dosage interval) or writing medication names without using capital letters.

After review by the expert panel, 281 newly prescribed or omitted items were found to be affected by 1 or more PEs, giving an error rate of 6.3% (95% CI 5.6-7.1%). Seven prescription items were affected by 2 PEs, giving a total of 288 detected errors. Table 1 displays PE rates by prescriber and stage of prescribing.

Orders prescribed on admission to hospital were associated with the highest PE rate (10.7% (95% CI 8.6-12.7%)) when compared to items prescribed during hospital stay (6.5% (5.3-7.8%)) or at discharge (6.5% (4.3-8.6%)). In contrast, items assessed on leave prescriptions (4.5% (1.9-7.0%)) and those that were re-written by prescribers (3.6% (2.6-4.6%)) had lower PE rates. Speciality trainees (general practitioner or psychiatry) were responsible for the majority of newly written or omitted items (52.8%) and had the highest PE rate (6.8% (5.8-7.8%)) after unknown prescribers (7.9% (4.6-11.1%)). Junior FY doctors generally had PE rates lower than their senior colleagues (FY one 5.1% (2.2-8.0%); FY two 4.9% (3.0-6.7%); staff grade 6.5% (4.2-8.7); consultant 5.8% (3.9-7.7%)).

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Table 1: Summary of prescribing errors by prescriber and prescribing stage

PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
FY1*	Items written/omitted	28	68	46	17	57	0	**216**
	Errors found	1	3	2	0	5	0	**11**
	% error rate (95% confidence intervals)	3.6% (0.0-10.6%)	4.4% (0.0-9.3%)	4.3% (0.0-10.3%)	0% (N/A)	8.8% (1.4-16.2%)	-	**5.1% (2.2-8.0%)**
FY2	Items written/omitted	95	124	179	79	59	0	**536**
	Errors found	5	9	5	5	2	0	**26**
	% error rate (95% confidence intervals)	5.3% (0.7-9.8%)	7.3% (2.7-11.8%)	2.8% (0.4-5.2%)	6.3% (0.9-11.7%)	3.4% (0.0-8.0%)	-	**4.9% (3.0-6.7%)**
Speciality Trainee**	Items written/omitted	582	734	636	114	270	0	**2336**
	Errors found	67	50	26	3	13	0	**159**
	% error rate (95% confidence	11.5%	6.8%	4.1%	2.6%	4.8%	-	**6.8%**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	intervals)	(8.9-14.1%)	(5.0-8.6%)	(2.5-5.6%)	(0.0-5.6%)	(2.3-7.4%)		**(5.8-7.8%)**
Staff Grade Psychiatrist	Items written/omitted	42	148	203	18	38	16	**465**
	Errors found	10	9	5	2	4	0	**30**
	% error rate (95% confidence intervals)	23.8% (10.8-36.9%)	6.1% (2.2-9.9%)	2.5% (0.3-4.6%)	11.1% (0.0-26.1%)	10.5% (0.6-20.4%)	0%	**6.5% (4.2-8.7%)**
Consultant Psychiatrist	Items written/omitted	30	378	124	13	38	3	**586**
	Errors found	3	23	4	0	4	0	**34**
	% error rate (95% confidence intervals)	10.0% (0.0-20.9%)	6.1% (3.7-8.5%)	3.2% (0.1-6.3%)	0%	10.5% (0.6-20.4%)	0%	**5.8% (3.9-7.7%)**
Pharmacist Prescriber	Items written/omitted	0	3	0	0	7	0	**10**
	Errors found	0	0	0	0	0	0	**0**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	% error rate (95% confidence intervals)	-	0%	-	-	0%	-	**0%**
Nurse Prescriber	Items written/omitted	0	12	0	0	0	0	**12**
	Errors found	0	0	0	0	0	0	**0**
	% error rate (95% confidence intervals)	-	0%	-	-	-	-	**0%**
Unknown Prescriber	Items written/omitted	86	63	85	6	26	0	**266**
	Errors found	6	6	4	1	4	0	**21**
	% error rate (95% confidence intervals)	7.0% (1.6-12.4%)	9.5% (2.2-16.8%)	4.7% (0.2-9.2%)	16.7% (0.0-49.3%)	15.4% (1.2-29.5%)	-	**7.9% (4.6-11.1%)**
TOTAL	Items written/omitted	**863**	**1530**	**1273**	**247**	**495**	**19**	**4427**
	Errors found	**92**	**100**	**46**	**11**	**32**	**0**	**281**

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PRESCRIBER	DESCRIPTION	PRESCRIBING STAGE						TOTAL
		On admission	During stay	Rewritten	Leave	Discharge	Unknown	
	% error rate (95% confidence intervals)	**10.7% (8.6-12.7%)**	**6.5% (5.3-7.8%)**	**3.6% (2.6-4.6%)**	**4.5% (1.9-7.0%)**	**6.5% (4.3-8.6%)**	**0%**	**6.3% (5.6-7.1%)**

* The Foundation Year (FY) programme corresponds to the first two years of medical training for junior doctors after completion of their undergraduate degree, and is similar to internships or residencies in other countries.

** Speciality trainees include General Practitioner trainee (GPST1-3) and psychiatry trainee (CT1-2 and ST4-6) medical grades; FY = Foundation Year

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Nature of PEs identified

The vast majority of identified PEs were associated with the oral route of administration (n=216, 75%) and medicines belonging to the central nervous system class (n=165, 57.3%).

The most common types of PEs were medicines omitted on admission to hospital (n=36, 12.5%), followed by administration times/frequencies that were incorrect or missing (n=33, 11.5%), missing strengths or doses (n=30, 10.4%) and prescribing incorrect drug formulations (n=26, 9.0%). Other common PE subtypes included failing to sign a prescription (n=24), incorrect or missing start dates for prescriptions (n=21) and under-dosing (n=20). Table 2 shows the frequency of all PE subtypes. After review by the multidisciplinary panel, 162 (56.3%) PEs were considered clinically relevant for patients. No PEs were reported by pharmacists to cause actual patient harm. These findings are summarised in Table 3 and a summary of all potentially serious and life-threatening errors is provided in Table 4.

Half of the 20 potentially serious or life threatening PEs involved central nervous system medicines, with the remaining 10 including cardiovascular system (n=5), endocrine system (n=4, all insulin) and anti-infective therapies (n=1). These error types occurred more commonly in female patients (n=14) and most frequently involved clinical contraindications (n=6), omission on admission (n=5) and missing strengths or doses (n=4); 3 female patients accumulated 11 of these errors, with one affected by 4 clinical contraindications, another with 4 with missing strengths/doses and the final patient with 3 drugs omitted on admission. In contrast, 25% of all potentially serious or life-threatening PEs involved injectable administration routes (subcutaneous route (n=4) or intramuscular (n=1) compared with total of 20/288 (6.9%) overall).

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Table 2: Types of prescribing errors

Type of prescribing error	Subtypes	Frequency (%)
Need for drug	Omission on admission	36 (12.5)
	Omission of discharge/leave prescription	14 (4.9)
	Duplication	13 (4.5)
	Continuation for longer than needed	10 (3.5)
	Omission on rewritten prescription	3 (1.0)
	Drug not prescribed but indicated	1 (0.3)
	No indication	1 (0.3)
	Premature discontinuation	0
Selection of specific drug	Clinical contra-indication	9 (3.1)
	Unintentional prescription of drug	2 (0.7)
	Continuation after adverse drug reaction	0
	Drug interaction	0
	Significant allergy	0
Select dosage regimen	Underdose	20 (6.9)
	Overdose	12 (4.2)
	No maximum dose	5 (1.7)
	Drug interaction not taken into account	1 (0.3)
	Dose / rate mismatch	0
	No dosage alteration after levels out of range	0
	Daily dose divided incorrectly	0
Administration of drug	Administration times/frequencies incorrect/missing	34 (11.8)
	Incorrect formulation	26 (9.0)
	Start date incorrect/missing	21 (7.3)
	Intramuscular instructions incorrect/missing	0
	Incorrect route	0
Provide drug product	Strength/dose missing	30 (10.4)
	No signature	24 (8.3)
	Product/formulation not specified	17 (5.9)

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Type of prescribing error	Subtypes	Frequency (%)
	Prescribed medication not in accordance with Mental Health Act documentation	4 (1.4)
	Route missing	3 (1.0)
	Controlled drug requirements incorrect/missing	1 (0.3)
	Prescription initiated before registration with monitoring service	1 (0.3)

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Table 3: Severity ratings for identified PEs following multidisciplinary review

Potential severity criteria		Examples	Frequency (%)
Not clinically relevant	Minor	Prescription not signed. No start date on prescription.	126 (43.8)
Clinically relevant prescribing errors	Significant	The dose of the drug is too low for a patient with the condition being treated. The wrong route of administration for the condition being treated is ordered e.g. intramuscular depot is prescribed for subcutaneous administration.	142 (49.3)
	Serious	The dose of the drug would result in serum drug levels in the toxic range, e.g. lithium levels 1-2 mmol/L. The drug orders could exacerbate the patient's condition, e.g. drug-drug interaction or drug-disease interaction.	19 (6.6)
	Life-threatening	The drug prescribed has a high potential to cause a life threatening adverse reaction, such as anaphylaxis, in light of the patient's medical history. The dose of a potentially life-saving drug is too low for a patient having the disease being treated.	1 (0.3)

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Table 4: Descriptions of potentially serious and life-threatening prescribing errors

Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
Potentially life threatening	46	Male	Zuclopenthixol Decanoate	300mg weekly	Schizophrenia	Intramuscular	Clinical Contraindication: Patient prescribed this medication after previous prolonged QTc whilst taking olanzapine (no QTc values provided). After olanzapine stopped and zuclopenthixol started, no further ECG taken despite receiving two doses of depot (one of which was an increased dose)
Potentially serious	76	Female	Moxonidine	400 micrograms	Hypertension	Oral	Clinical contraindication: Medication continued on rewritten prescription despite very low blood pressure recorded.
			Bisoprolol	5mg	Hypertension	Oral	As above – same patient
			Lisinopril	10mg	Hypertension	Oral	As above – same patient
			Doxazosin	16mg	Hypertension	Oral	As above – same patient
Potentially serious	26	Female	Quetiapine	450mg	Personality disorder	Oral	Omission on admission: Medicine not prescribed upon inpatient admission
			Diazepam	15mg	Personality disorder	Oral	As above – same patient – doses missed
			Mirtazapine	45mg	Personality disorder	Oral	As above – same patient – doses missed
Potentially serious	48	Female	Novorapid insulin	6 units AM	Diabetes	Subcutaneous	Dose/strength missing: Insulin dose prescribed as 'U' instead of 'Units' which could have been mistaken for 0 i.e. 10 fold error

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Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
			Novorapid insulin Novorapid insulin Novorapid insulin	4 units PM 6 units PM 4 units PRN	Diabetes Diabetes Diabetes	Subcutaneous Subcutaneous Subcutaneous	As above – same patient As above – same patient As above – same patient
Potentially serious	78	Female	Haloperidol	4mg	Psychotic depression	Oral	Under-dose: Dose prescribed on admission as 500 micrograms twice daily – only 25% of normal dose
Potentially serious	32	Female	Sodium valproate	500mg	Epilepsy	Oral	Omission on admission: Medication not prescribed on admission – dose missed
Potentially serious	32	Male	Enalapril	20mg	Hypertension	Oral	Overdose: Prescribed as 200mg daily on admission – 10 times overdose
Potentially serious	Unknown	Male	Co-trimoxazole	960mg	Pneumocystis pneumonia prophylaxis	Oral	Omission on admission: Failure to prescribe on admission to hospital
Potentially serious	79	Male	Risperidone	3mg	Psychosis	Oral	Duplication: Dose increased from 1mg twice daily to 1.5mg twice

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Severity	Patient age	Patient sex	Medication	Daily dose (intended)	Indication	Route of administration	Error description
							daily, but old entry not cancelled.
Potentially serious	44	Male	Citalopram	30mg	Depression	Oral	Omission on discharge/leave prescription: Omitted from discharge prescription
Potentially serious	Unknown	Female	Clozapine	Titration	Psychosis	Oral	Clinical contra-indication: despite efforts to slow pace of clozapine dose escalation (due to tachycardia), dose increased by 50mg daily
Potentially serious	34	Male	Sodium valproate MR	1700mg	Siezures	Oral	Under dose: On admission, missed off 700mg morning dose

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Predictors of PEs

Multivariate logistic regression analysis found that specialist trainee registrars (OR 1.23, 95% CI 1.01-1.51) and staff grade psychiatrists (OR 1.50 (1.05-2.13)) were more likely to make PEs than more junior foundation year 1 doctors (FY1) when controlling for prescribing stage, electronic discharge prescriptions and when clustered for study site (as shown in Table 5).

When compared to items written or omitted during the patients stay, prescribers were less likely to make PEs when medication charts were rewritten or when patients were discharged home (OR 0.52 (0.33-0.82) and 0.87 (0.79-0.97) respectively). Newly written or omitted items on admission showed no differences in risk of PEs (OR 1.81 (0.51-6.37)) nor did items written or omitted for patient leave (OR 0.66 (0.39-1.11)) when compared to those screened during patient stay. No difference in risk of PE was observed when discharge prescriptions written on a standard electronic pro-forma were compared to handwritten counterparts (OR 1.30 (0.72-2.35)).

Predictors of clinically relevant PEs

As shown in Table 5, multivariate logistic regression analysis revealed that more experienced medical staff were more likely to make a clinically relevant PE than their junior counterparts (FY1), with speciality trainee registrars (General Practitioner or psychiatry) and consultant psychiatrists being twice as likely to do so (OR 2.61 (2.11-3.22) and 2.03 (1.66-2.50) respectively).

Patient admission and discharge were associated with a significantly increased risk of making a potentially clinically relevant PE when compared with during stay (OR 5.39 (2.72-10.69) and 4.23 (3.68-4.87) respectively), with the process of rewriting prescriptions also at

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significantly higher risk (OR 2.27 (1.72-2.99)). No difference in risk was observed when leave prescriptions were compared to those written during patient stay.

When compared against those errors associated with the 'need for drug' PE subcategory, the groups 'select dosage regimen', 'administration of drug' and 'provide drug product' were associated with a lower risk of potentially clinically relevant PEs (OR 0.44 (0.20-0.97), 0.17 (0.09-0.32), 0.04 (0.02-0.12) respectively). The latter two groups in particular were associated with much lower risks; PE types included in these groups were mostly clerical in origin (e.g., missing prescriber signature, see Table 2).

Neither prescriptions written on a standard electronic pro-forma (OR 0.92 (0.38-2.22)) nor the central nervous system medication class (OR 0.71 (0.34-1.49)) were associated with an increased likelihood of clinically relevant PEs when compared to minor errors.

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Table 5: Predictors of (a) error likelihood and (b) potential error severity: multivariate logistic models

FACTOR		ODDS OF PRESCRIBING ERROR COMPARED TO NO ERROR		ODDS OF CLINICALLY RELEVANT PRESCRIBING ERROR RATHER THAN A MINOR ERROR*	
		Odds ratio (OR)	95% CI	Odds ratio (OR)	95% CI
Prescriber	**FY1**	Reference		Reference	
	FY2	0.96	0.84 – 1.11	1.83	0.77 – 4.38
	Speciality Trainee **	**1.23**	**1.01 – 1.51**	**2.61**	**2.11 – 3.22**
	Staff Grade Psychiatrist	**1.50**	**1.05 – 2.13**	2.88	0.70 – 11.83
	Consultant Psychiatrist	1.18	0.71 – 1.95	**2.03**	**1.66 – 2.50**
Prescribing stage	**During stay**	Reference		Reference	
	Admission	1.81	0.51 – 6.37	**5.39**	**2.72 – 10.69**
	Re-written item	**0.52**	**0.33 – 0.82**	**2.27**	**1.72 – 2.99**
	Leave	0.66	0.39 – 1.11	2.57	0.74 – 8.95
	Discharge	**0.87**	**0.79 – 0.97**	**4.23**	**3.68 – 4.87**
Electronic discharge pro-forma item	**No**	Reference		Reference	
	Yes	1.30	0.72 – 2.35	0.92	0.38 – 2.22
Medication class ┼	**All others**	-	-	Reference	
	Central Nervous System	-	-	0.71	0.34 – 1.49
Prescribing error subcategories ***	**Need for drug**	-	-	Reference	
	Selection of specific drug	-	-	2.36	0.23 – 24.48
	Select dosage regimen	**-**	**-**	**0.44**	**0.20 – 0.97**
	Administration of drug	**-**	**-**	**0.17**	**0.09 – 0.32**
	Provide drug product	**-**	**-**	**0.04**	**0.02 – 0.12**
Pseudo R squared values		**0.02**		**0.28**	

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FACTOR		ODDS OF PRESCRIBING ERROR COMPARED TO NO ERROR		ODDS OF CLINICALLY RELEVANT PRESCRIBING ERROR RATHER THAN A MINOR ERROR*	
		Odds ratio (OR)	95% CI	Odds ratio (OR)	95% CI

FY = Foundation Year; * Potentially clinically relevant PEs (either significant, serious of life-threatening) vs. minor errors; ** Speciality trainees include GPST1-3, CT1-2 and ST4-6 medical grades; *** see table 2 for a list of PE subcategories; ┼ = no odds ratio for risk of at least one PE as no denominator data collected for medication classes

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DISCUSSION

Main findings

This is the first study to prospectively identify the prevalence, nature and predictors of inpatient prescribing errors in mental health hospitals for only newly written or omitted prescription items, finding an overall rate of 6.3% (95% CI 5.6-7.1%). Most of the PEs identified related to omissions of drugs on admission to or discharge from hospital as well as missing or incorrect prescription requirements (e.g. dose, frequency, signatures, formulations). Over half (56%) of all 288 errors identified were considered to be clinically relevant with the potential to cause patient harm, with 20 (6.9%) being graded as potentially serious or life-threatening. Speciality trainees and staff grade psychiatrists were more likely to make a PE, with speciality trainees and consultants more likely to make a potentially clinically relevant PE. Rewritten and discharge prescription items were significantly less likely to contain a PE than those written during patient stay, but were found to be at higher risk of potentially clinically relevant errors (especially on admission and discharge, where the risk was 5 and 4 times that of during stay, respectively). PE subtypes including prescription writing errors were associated with significantly lower risks of potentially clinically relevant PEs when compared to groups which included omitted and duplicated drugs. Electronic prescribing at discharge using a template and the 'central nervous system' drug class (which contains all psychotropic medicines) were found not to be associated with an increased risk of clinically relevant PEs.

Implications of findings

Our overall PE rate of 6.3% is higher than the 2.2%[18] and 2.4%[22] previously reported in UK psychiatric hospitals using prospective medication chart review, and similar to a median

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rate of 7 per 100 medication orders reported in general hospitals worldwide.[2] However, differences in the type of prescription items that were assessed (i.e. we included only newly omitted and written items), the data collection periods (4 days[18] or 5 days[22] versus 10 in this study), severity assessments, study settings and year of publication preclude more direct comparisons.[2,34] Recent UK based general hospital PE investigations using similar methodology as this study reported higher PE rates,[7,8] which may reflect different patient complexities, the working environment, the medicines used (e.g. intravenous medicines are rarely used in psychiatry) and the predominant focus on mental health rather than physical health in psychiatry settings. In contrast, retrospective reviews of case notes / medication charts to identify PEs in psychiatry[25] yields higher error rates of 15% of error opportunities although the denominator and setting of this study was different to ours.

The finding that a sizeable proportion of PEs concerned dosing errors or incomplete prescription items has been noted in other studies of PEs in psychiatry,[18,20,22] and in general hospitals.[2,7-9] However, whilst studies in general hospitals also found that the omission of drugs on admission/discharge/rewritten prescriptions were a leading PE subtype,[2,7-9] previous studies in psychiatry did not.[18,20,22] ~~which could relate to~~ Omission of drugs on patient transfer may arise due to inadequate communication of drug information[8,35] an issue which may affect mental health settings more acutely given the increasing number of community services creating more care transfer interfaces.[13,36,37] One UK study found that 69% and 43% of hospital admission and post-discharge medicines were affected by a medication discrepancy, respectively[17] and more recently studies found 56.2% of hospital admissions (UK based)[38] and 23.3% of discharges (USA based)[39] were affected, with the most common types being drug omissions. These studies highlight the importance of

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medicines reconciliation, a practice which is established in UK mental health hospitals[40] and which has shown value across hospital settings.[38,40-42]

Despite the prevalence of drug omission errors during care transfer the patient admission stage was not associated with significantly higher PE rates than during patient stay in this study, with the re-write and discharge stages associated with a significantly lower risks of PEs. However, errors occurring on admission, re-write and discharge were more likely to harm patients (considered as clinically significant errors – potential to cause significant, serious or life-threatening harm), which could reflect the fact that errors could cause immediate deterioration in a patients clinical condition and/or go unnoticed for long periods of time. The clear dangers posed by patient transfer in psychiatry have been recognised nationally in the UK,[37,43] though overall this challenge has received less attention than in general hospitals.[13,15,36] Future research should seek to clarify the frequency, nature and severity of PEs across and between care interfaces in the mental health setting, as well as investigating further the impact of medicines reconciliation.

This study has indicated that more senior speciality trainees and staff grade psychiatrists are at a significantly increased risk of making a PE when compared to their FY one colleagues. This is in contrast to the EQUIP study, which found that junior doctors were more likely to make PEs.[7] The regression analysis also revealed that consultants were at a higher risk of making potentially clinically relevant PEs, along with speciality trainees when compared to FY one doctors. Whilst senior doctor prescribing has not been formerly evaluated in psychiatry in relation to PEs, the bulk of prescribing on admission and discharge (where more clinically significant errors occurred) was carried out by speciality trainees, which may explain why this association was found. Consultant prescribing may be more complex and risky than junior doctor prescribing, with negative perceptions towards prescription re-writes

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from medical staff noted in research from general hospitals also potentially contributing.[11] Future research should investigate in detail the prescribing of more senior clinicians in mental health, as previous studies making similar comparisons did not do so in the context of total prescribing burdens using multivariate regression analysis.[18,22]

This study has emphasised the importance of pharmacy teams in the detection and prevention of PEs and associated patient harms in mental health hospitals, as seen elsewhere.[9,18,20,22,25,38] ~~Despite their important contribution to medicines safety and governance there has been less investment in pharmacy services in UK mental health when compared to acute hospitals.[43,44]~~ Given the important contribution of medicines to avoidable harm in hospitals, the input of pharmacy teams in keeping patients safe should not be underestimated.[43,~~44~~]

Our analysis did not reveal any difference in the risk of a PE between electronic and hand written prescriptions, though this should be viewed with caution as the number of electronically prescribed items in our analysis was low and the nature of this type of prescribing was limited to discharge prescription templates at one study site (i.e. no commercially available e-prescribing software was used). Although the benefits of electronic prescribing software should not be overlooked[15] further investigation may be required as despite important reductions in some errors the wider effects of electronic prescribing systems on MEs and ADEs is not clear, and in some cases novel PE opportunities may be created.[44]

To our knowledge, there have been no published attempts to determine the causes of PEs in inpatient mental health settings despite growing understanding in general hospitals that these errors involve multiple, interacting antecedents.[7,8,10-12] Although a number of different interventions designed to reduce PEs have been suggested,[45] future research should focus on determining the causes of PEs in psychiatry using theoretical frameworks such as Reason's

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Model of Accident Causation[46] as recommended previously.[13,15,47] Reason's model has been used frequently in general hospitals for this purpose,[7,10-12] and such investigations would facilitate measurement of the value of remedial interventions in the psychiatry setting. As a large proportion of care for mental health patients takes place in the community, future studies of PEs could also be carried out in this setting.[13,36]

Strengths and limitations

Key strengths of this study are that it ~~was larger[18,20] and lasted for a longer duration[18,22] than previous work,~~ used standardised training of data collectors, sought to compare risk of PEs and clinically relevant errors between prescribers and prescribing stages, and collected data on only newly written or omitted items over a range of data collection days so that items were counted only once and the risk of including previously corrected items was minimised.

Although this study was conducted across three sites over a large geographical area, generalizability may be limited when compared to earlier work.[22] Combined medication chart and case note review may identify a greater number of PEs,[30] so our PE rate maybe an underestimate of the true burden of these errors in mental health hospitals. Whilst data collectors were trained using standardised materials it is impossible to exclude variation in error detection due to differing workloads,[48] vigilance and/or individual clinical experience of collectors.[9,22] The rate of false positives was minimised by using a multidisciplinary PE review panel, one senior member of which (SDW) had previously evaluated prescribing errors in a much larger study.[7] We did not record separate PE rate data for core medical versus general practitioner speciality trainees or psychotropic versus non-psychotropic medicines, which means that we were unable to compare these different groups.

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The fact that unknown prescribers were associated with the highest PE rate (7.9% (4.7–11.1%)) highlights the need to ascertain the identity of prescribers as well as when and where prescribing took place in order to facilitate optimal patient care and rectify mistakes promptly. Prescriber identification becomes an even more critical issue given the more recent emphasis on the importance of feedback to improve prescribing practice and minimise PEs.[7,8,45,49]

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CONCLUSION

Prescribing errors may be more common in mental health hospitals than previously reported, and continue to post a significant challenge to healthcare providers as the majority have the potential to cause patient harm. This study has identified more senior prescribers and care transfer interfaces as potential targets to investigate the burden of these errors in more detail with the aim of formulating remedial approaches. Future work should focus on using theoretical frameworks such as those of human error to investigate the causes of PEs in order to inform the design of interventions aimed at reducing their burden in the psychiatric inpatient setting.

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Competing interests

All the authors have no competing interests to declare. This work has not been posted or published elsewhere in its entirety. An abstract summarising the study will soon be published after oral presentation at the Prescribing and Research in Medicines Management (PRIMM) Annual Scientific Meeting 2014 (2nd May, London, UK).

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Design of study: all authors. Review of study data (expert panel): RNK, JJV, SDW. Analysis of data: RNK, DMA. Preparation of manuscript: RNK. Critical review of manuscript: all authors. Approval of submitted manuscript (current version): all authors.

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