A study of Foundation Year doctors prescribing in patients with kidney disease at a UK renal unit: a comparison to other prescribers for the frequency, medicine associated, and nature of errors.

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ABSTRACT

Objectives

Errors in the process of prescribing can lead to avoidable harm for patients. Establishing the extent of prescribing errors across medical specialties is critical. This research explores the frequency and types of prescribing errors made by healthcare professionals prescribing in patients with renal disease where prescribing problem-solving and decision-making is complex due to co-existing multimorbidity

Methods

All prescriptions and errors made by prescribers were captured over a four-month period at a UK renal unit. Data was recorded about the medicine associated with error, the nature and severity of error, alongside the prescriber's occupational grade.

Results

There were 10394 items prescribed and 3.54% with associated prescribing errors. Whilst Foundation year one doctors made almost one error every week (n=15.13) and Foundation year two doctors one every two weeks (n=8.00), other prescribers made one error per month (n=3.94, 95%). The medicines most frequently associated with errors for Foundation doctors were paracetamol (6.51%), calcium acetate (5.33%), meropenem (3.55%), alfacalcidol (3.55%) and tazocin (3.55%), whilst for all other prescribers they were meropenem (6.15%), alfacalcidol (4.62%), co-amoxiclav (4.62%) and tacrolimus (4.62%). The most common types of error for both groups were omitting the indication, using the brand name inappropriately, and prescribing inaccurate doses.

Conclusions

The range of errors made by multi-professional healthcare prescribers confirms complexity of prescribing on a renal unit for patients with kidney disease and multimorbidity. These findings have implications for the types of educational interventions required for reducing avoidable harm and overcoming human factors challenges to improve prescribing behaviour.

KEYWORDS

foundation doctors

hospital pharmacy

medical education

medical errors

renal pharmacy

safe prescribing

human factors.

KEY MESSAGES

What is already known on this subject?

- Prescribing errors, especially amongst Foundation Year doctors (doctors who are in their first two years of practice following graduation from medicine in the UK), are common and an avoidable cause of adverse harm involving medication.
- Prescribing medicines to patients with kidney disease is complex and challenging due to the high prevalence of multimorbidity and a greater risk of polypharmacy.
- There is little research exploring the nature of prescribing errors in patients with kidney disease.

What this study adds

- Prescribing errors at a specialist renal unit was compared to other studies but contained a higher proportion with the potential to cause severe consequences.
- The quantity of prescribing errors among Foundation Year doctors were associated with their years of clinical experience. Foundation Year one doctors made twice the number of errors as Foundation Year two doctors, and Foundation Year two doctors made twice the number of errors as other prescribers.
- Paracetamol was most frequently associated with prescribing errors made by Foundation Year doctors.
- Further research is required to develop appropriate interventions based on the insights from this study and identify total educational solutions that also seek to overcome the human factors elements to prescribing errors.

INTRODUCTION

Patients with kidney disease across the spectrum of acute kidney injury through to chronic kidney disease (CKD) requiring renal replacement therapy are particularly vulnerable to avoidable harm from medication.[1 2] Patients with CKD tend to be older than the general population and so have a high number of long term conditions and multimorbidity which requires management with medication.[3 4] As a consequence of this disease burden, patients with CKD are also at risk of a greater pill burden, otherwise known as polypharmacy.[5] Increased patient age, multimorbidity and polypharmacy all lead to greater risk of adverse medicine reactions so preventing avoidable harm from medication in this group of patients is particularly important.[6] Medicine dose and dose interval adjustments are an important part of this strategy. However, calculations can be complicated and the risk of potential harm from prescribing errors remains.[1 7 8] Furthermore, some of the medicines used in renal medicine and transplantation are subject to clinically significant drug and food interactions that can also result in patient harm. Consequently, patients with kidney disease remain vulnerable to avoidable harm and adverse events due to complications from incorrectly prescribed medicines.

Safe prescribing is a key element of any patient safety initiative in healthcare. Dean et al defined a prescribing error as "an unintentional significant (1) reduction in the probability of treatment being timely and effective or (2) increase in the risk of harm when compared with generally accepted practice".[9(p235)] Prescribing errors are common in the workplace with reported rates between 7% and 15%.[10 11] Establishing the nature of prescribing errors in relation to the professional group and occupational grade of the prescriber reveals a more nuanced understanding of the errors. In a study of prescribing errors of inpatients in UK hospitals, Dean et al observed that junior doctors were responsible for the greatest proportion of prescription errors.[12] Dornan et al reported that doctors in the first two years of qualified practice were more likely to make a prescribing error compared to other prescribers such as consultants, nurses or pharmacists.[13] These differences in prescriber occupation warrant further attention since there is evidence that pharmacists make almost no medical errors when prescribing.[14] Dornan et al's findings also suggests that prescribing behaviour of prescribers, particularly Foundation Year doctors, requires close attention, with hospital admission associated with a greater risk that patients may suffer a prescribing error.[13]

Given the potential threat to patient safety posed by inexperienced Foundation Year (FY) doctors (doctors in their first two years of practice following graduation from medicine in the UK), increasing the effectiveness of their prescribing is paramount. A variety of educational interventions to improve prescribing competency have been proposed. Following a recent systematic review, Kamarudin et al identified that the most evidence for improving prescribing competence relates to training medical professionals is the use of the WHO Guide to Good Prescribing.[15] They also report continuing education and personalised feedback to yield positive results.[15]

Alongside these educational interventions, references such as the Renal Drug Handbook[16] and the Electronic Medicines Compendium[17] support FY doctors with prescribing for patients with kidney disease. Whilst these resources exist and can be found in the workplace, it remains unclear whether making more of these available can support FY doctors prescribe safely in patients with kidney disease. FY doctors perceive renal medicine as difficult and

challenging particularly around acid-base, electrolyte disorders and dialysis.[18] As a result, Jhaveri et al suggest alternate and innovative methods of teaching renal medicine were necessary given this complexity,[18] however there are few descriptions of alternatives to traditional textbooks or manuals for teaching FY doctors how to prescribe in patients with kidney disease.

Jhaveri et al found that FY doctors wanted more practical prescribing education and explicit feedback on their prescribing performance when prescribing in general contexts.[18] In order to develop such practical education for FY doctors, it is important to gain a better understanding about the prescribing performance of these individuals within each prescribing context. Besides informing a targeted programme of education, elucidating the nature of prescribing errors and the most common medicines involved in errors will provide guidance on how best to design and deliver education in partnership with other health professionals such as pharmacists and nurses.

The prevalence of prescribing errors is widely reported.[2 8 10 11 12 13 19 20 21 22] Yet there is little information about the nature of the problem in specific prescribing contexts such as a renal unit or among patients with renal disease. Without this context specificity, the prevalence of prescribing errors for informing targeted educational interventions is limited. Although the nature of prescribing errors observed in a renal unit has been previously reported in a study in Iran, there is no study specifically exploring the prevalence and nature of these prescribing errors amongst FY doctors in the UK.[22]

The aim of this research was to explore the types of errors in relation to the medicines involved, the nature and severity of error made by FY doctors when prescribing in patients with kidney disease. This information will provide a better understanding of the educational needs around prescribing of FY doctors working in UK renal units compared to other healthcare professionals.

METHODS

Context

Clinical pharmacists reviewed all handwritten medicines prescribed on in-patient medication charts over a four-month FY doctor rotation period from April to the end of July 2013. The study was undertaken across four in-patient wards in a tertiary centre renal unit at a UK teaching hospital based in the East Midlands. All patients were admitted under specialist renal care across four wards and a total of 59 beds.

Data collection and analyses

A paper-based data collection form adopted from Dornan et al[13] was designed and piloted for seven days, to ensure the team of six renal clinical pharmacists could reliably and practically use if for identifying and coding medication errors. The clinical pharmacists received training prior to the study in relation to capturing data and categorisation of error severity. Medicine prescribing errors were recorded during the usual review of medical charts undertaken by ward-based pharmacists to minimise disruption to clinical service. All prescribing errors were recorded alongside demographic details of the patient, prescriber details, location of the prescription, and details of the medicine prescribed. All prescribing errors detected were corrected as part of the pharmacists' clinical role in the unit. In order to determine the number of errors made in the renal unit in proportion to the number of total

prescriptions, the total number of medicine prescribed over the four-month period was recorded daily on weekdays from Monday to Friday. All error forms were peer reviewed by one of the senior renal pharmacists and to ensure the accuracy of data. Another senior renal clinical pharmacist peer reviewed the completed forms, and gained consensus from the wide team about the potential for harm to patients in the event the error was left undetected. The renal function of patients in whom errors were detected was calculated using the Cockroft-Gault equation and appropriate medication resource consulted to elucidate correct dosing (renal drug handbook[16], electronic medicines compendium[17], Micromedex, local guidelines). Data was anonymised prior to entry into a spread sheet for analyses. An intrinsic limitation of data collection about prescribing from hand written charts was the inability to capture real time prescribing information, therefore the total number of prescriptions made per prescriber were not captured in this study.

All errors were grouped according to the medicine name and error type for both FY doctors and all other prescribers. All errors were further categorised using the EQUIP criteria.[13] All errors sub-divided into serious or lethal, with those involving erythropoiesis-stimulating agents, antibiotics and phosphate binders were reported in more depth due to their specific relevance to the prescribing context in the renal unit. The nature of the prescribing errors were categorised into 37 'Error Types'.[13]

The study was completed as part of the University Hospitals of Leicester NHS Trust's commitment to ensuring patient safety and improving quality. The study was registered with the clinical effectiveness team in the Trust, reference number: 6608E. Therefore, all issues related to perceptions of surveillance and temporary behaviour changes were minimised.

The results are presented in six sections with a comparison between the two study groups: Foundation Year (FY) doctors, and all other prescribers, this group include senior trainees, nurses, a dietician, consultants and core trainees. The sections are: total number of errors, medicines associated with errors, nature of error, nature of renal specific error, severity of error, medicines specific to kidney disease and antibiotics.

The most junior members of the medical team only complete prescriptions made on discharge paperwork, therefore, errors in the prescribing process comprise a potentially different aetiology than those made on hand written charts. They also comprise a computer-generated output; therefore discharge data were excluded from analyses.

RESULTS

Total number of errors

In total, 10394 items were prescribed during the four-month study. Of these, the pharmacy team identified 368 (3.54%) as prescribing errors. A number of errors have been removed from the analyses due to missing information:

- 56 (15.2%) errors were not attributable to any prescriber due to signatures being omitted, unknown or unreadable.
- 13 (3.5%) errors were attributable to FY doctors not routinely based on the renal unit. These medicines are likely to have been prescribed by doctors during on call shifts, or when patients were elsewhere.

The FY doctors (n=14) made 169 (56.52%) prescribing errors, whilst the other prescribers (n=33) made 130. Whilst this looks like a similar prescribing performance, when we consider

the number of errors per prescriber (see Table 1), the results reveal FY1 doctors made almost four times as many prescribing errors as the all others prescribing group and twice as many as FY2 doctors, whilst the FY2 doctors made twice as many prescribing errors as the all others prescribing group.

Table 1: Prescribing error frequency by occupational grouping.

	Prescriber occupational grade		
	Foundation Year 1	**Foundation Year 2**	**All other prescribers**
Total no. of prescribers	8	6	33
Errors	121 (40.47%)	48 (16.05%)	130 (43.48%)
Mean number of errors per prescriber	**15.13**	**8.00**	**3.94**

Medicines associated with prescribing errors

Of the 299 prescription errors, 115 different medicines were involved. Table 2 shows a list of the most common medicines involved in prescribing errors by order of prevalence. The Total column gives the most prevalent medicines associated with errors such as Paracetamol, Calcium Acetate and Meropenem. The most common for the FY doctors are Paracetamol and Calcium Acetate, whilst for the All other prescribers it is Meropenem, Alfacalcidol, Co-amoxiclav and Tacrolimus. More than half of the medicines (n=65) were associated with only one error.

Table 2: Medicines most commonly related to a prescribing error by rank for group, number of observed prescribing errors and percentage within prescribing group.

	Total			**Foundation Year 1 and 2**			**All other prescribers**		
	(rank, observed, percentage)			(rank, observed, percentage)			(rank, observed, percentage)		
Paracetamol	1	15	5.02%	1	11	6.51%	9	4	3.08%
Calcium Acetate	2	14	4.68%	2	9	5.33%	4	5	3.85%
Meropenem	2	14	4.68%	3	6	3.55%	1	8	6.15%
Alfacalcidol	4	12	4.01%	3	6	3.55%	2	6	4.62%
Tazocin	5	11	3.68%	3	6	3.55%	4	5	3.85%
Co-amoxiclav	5	11	3.68%	6	5	2.96%	2	6	4.62%
Tacrolimus	7	10	3.34%	9	4	2.37%	2	6	4.62%
Darbepoetin alfa	8	9	3.01%	9	4	2.37%	4	5	3.85%
Dalteparin	9	8	2.68%	15	3	1.78%	4	5	3.85%
Insulin	10	7	2.34%	6	5	2.96%	15	2	1.54%
Flucloxacillin	10	7	2.34%	15	3	1.78%	9	4	3.08%
Sando-K	13	6	2.01%	9	4	2.37%	15	2	1.54%
Zopiclone	12	6	2.01%	9	4	2.37%	15	2	1.54%
Sevelamer	14	5	1.67%	6	5	2.96%	0	0	0.00%
Epoetin alfa	14	5	1.67%	15	3	1.78%	15	2	1.54%
Metronidazole	14	5	1.67%	32	1	0.59%	9	4	3.08%
Novomix 30	14	5	1.67%	32	1	0.59%	9	4	3.08%

Nature of error

When considering the nature of errors an additional 37 errors are included leading to a total of 336 errors. This is a result of 32 of the errors having two error types, and five having three error types. Table 3 shows the 10 most common Error Types recorded in the study by order of prevalence, with an example for each. The top three error types are consistent for the FY

doctors and the other prescribers, these are: ‘Omission – Indication’, ‘Brand Name’ and ‘Wrong Dose’.

Table 3: The top ten error types most commonly associated with observed prescription errors

		Total			Foundation Year 1 and 2			All other prescribers		
Error Type	**Example**	(rank, observed, percentage)			(rank, observed, percentage)			(rank, observed, percentage)		
Omission – Indication	Indication not specified when prescribing Oramorph	1	46	15.38%	1	21	12.43%	1	25	19.23%
Brand Name	Isosorbide Mononitrate prescribed by the brand name Monomil XL rather than generic name	2	33	11.04%	3	15	8.88%	2	18	13.85%
Wrong Dose	Loperamide prescribed as number of tablets rather than actual dose	3	32	10.70%	2	18	10.65%	3	14	10.77%
Abbreviation	Dose written as '0,25mcg' rather than '0.25 micrograms' in prescription of Alfacalcidol	4	15	5.02%	6	8	4.73%	5	7	5.38%
Wrong Frequency	Latanoprost prescribed to be taken twice daily rather than once daily	4	15	5.02%	4	12	7.10%	8	3	2.31%
Omission - Date	Date prescription made not specified when prescribing Dalteparin	6	13	4.35%	8	7	4.14%	6	6	4.62%
Omission - Course Length	Course length not specified in prescription of Tazocin to patient with diabetic foot	7	12	4.01%	10	4	2.37%	4	8	6.15%
Wrong Time	Meropenem prescribed intravenously to haemodialysis patient in the morning rather than at night (after haemodialysis)	8	11	3.68%	5	11	6.51%	11	0	0.00%
Omission – Frequency	Maximum daily frequency not specified when prescribing Paracetamol	9	9	3.01%	6	8	4.73%	10	1	0.77%
Duplication	Duplication of prescribed therapy	10	8	2.68%	9	6	3.55%	9	2	1.54%
Omission - signature	Prescriber’s signature is not eligible or not written	10	8	2.68%	10	4	2.37%	7	4	3.08%

Nature of renal specific errors

Examples of prescribing errors that are specific to kidney disease are provided in Table 4.

Table 4: Nature of error for renal specific errors, categorised by type of medication, error description, potential negative outcome and severity

Medication category	Error description	Potential negative outcome	Severity
Medicines used in chronic kidney disease	Prescription for 'Epo'. Inappropriate abbreviation used with no brand or dose specified	Prescription is unclear and therefore nursing staff would be unable to administer the medication. As a consequence, the patient may not receive the treatment or it could lead to inappropriate delays.	Severe
	Calcium Carbonate prescribed as a phosphate binder for a patient with hypercalcaemia	Exacerbation of hypercalcaemia potentially leading to clinical manifestations such as lethargy, weakness, confusion, coma, constipation, nausea, anorexia and arrhythmias.	Severe
Anticoagulation	Treatment dose for a deep venous thrombosis of dalteparin (12500 units once daily) prescribed for a patient on haemodialysis	Low molecular weigh heparins given at conventional treatment doses to patients on haemodialysis will accumulate, which can complicate reversal of anticoagulation.	Severe
Antimicrobials	Clarithromycin prescribed in combination with tacrolimus and atorvastatin (significant interactions)	Increased exposure to atorvastatin and tacrolimus, which could lead to toxicity such as myopathy (atorvastatin) and nephrotoxicity and neurotoxicity (tacrolimus)	Severe
	Wrong dose of ganciclovir prescribed (500 mg tds instead of 500 mg bd)	Increased exposure to ganciclovir, which could lead to toxicity such as neurotoxicity and myelosuppression	Severe

	Incorrect (too high) dose of meropenem prescribed for a patient receiving haemodialysis	Increased exposure to meropenem which could lead to toxicity such as neurotoxicity.	Severe
	Valganciclovir unintentionally omitted from a renal transplant patient medication card and treatment was required	Omitting valganciclovir in these cases could result in increased risk of CMV disease.	Severe
Immunosuppression	Treatment with mycophenolate mofetil inadvertently continued for a renal transplant patient with cytomegalovirus infection	If immunosuppression is not minimised, this could compromise success of treatment of CMV disease in renal transplant patients.	Severe
	New transplant patient whose medication chart did not include any immunosuppression or adjuvant agents given after renal transplantation. This patient was however prescribed inappropriate medicines such as high dose furosemide and phosphate binders (no longer indicated)	Lack of prescribed immunosuppression following renal transplantation will increase the risk of acute rejection and graft loss.	Severe
	Incorrect Prograf dose. Prescribed as 500 mg instead of 500 micrograms	Although it is unlikely that the dose would have been given (100 capsules of 5 mg would have to be administered), this error constitutes a 1000 times overdose which would result in fatality almost certainly.	Lethal

Potential severity of error

The potential severity of error is consistent between the FY and other prescriber groups (Table 5), with a similar percentage of minor and significant errors and fewer serious errors. One lethal error, attributed to a FY2 doctor, was recorded in a prescription of the immunosuppressant medicine Tacrolimus with 500 milligrams prescribed rather than 500 micrograms.

Table 5: Prescription errors recorded by potential severity of error

Potential Severity of Error	Example	Total		Foundation Year 1 and 2		All other prescribers	
Minor	Simvastatin prescribed in the morning rather than at night	129	43.14%	66	39.05%	63	48.46%
Significant	No maximum frequency stated when Paracetamol prescribed	124	41.47%	73	43.20%	51	39.23%
Serious	Co-amoxiclav prescribed to patient with known penicillin allergy	45	15.05%	29	17.16%	16	12.31%
Lethal	500 mg of Tacrolimus prescribed instead of 500 micrograms	1	0.33%	1	0.59%	0	0.00%
Total		299	100%	169	100%	130	100%

Medicines specific to kidney disease

Erythropoiesis-stimulating agents were recorded as being involved in 5.02% of errors (n=15). The medicines involved are Darbepoetin alfa (FY n=4, Others n=5), Epoetin alfa (FY n=3, Others n=2) and Erythropoietin (FY 1).

Phosphate binders were involved in almost 9% of errors (n=24), tabulated in Table 6. Calcium acetate was found to be the most common bone biochemistry medicine associated with prescribing errors. Nine phosphate binders prescribing errors were classified as minor (36%), fourteen as significant (60%) and one as serious (4%).

Table 6: Phosphate binders most commonly associated with prescribing errors

Phosphate binders	**Total** (rank, observed and percentage)			**Foundation Year 1 and 2** (rank, observed and percentage			**All other prescribers** (rank, observed and percentage)		
Calcium acetate	1	14	56.00%	1	9	50.00%	1	5	71.43%
Sevelamer	2	5	20.00%	2	5	27.78%	3	0	0.00%
Lanthanum carbonate	3	4	16.00%	3	3	16.67%	2	1	14.29%
Adcal D3®	4	1	4.00%	4	1	5.56%	3	0	0.00%
Total		24	100%		18	100%		6	100%

Antibiotics

Antibiotic medicines were recorded in almost 20% of errors (n=58), tabulated in Table 7. Meropenem and Tazocin were subject of almost 25% of these with Doxycycline and Co-Amoxiclav following (19%). This was relatively consistent for FY doctors and all other prescribers.

Table 7: Antibiotic medicines most commonly associated with prescribing errors

Antibiotic medicine	**Total** (rank, observed and percentage)			**Foundation Year 1 and 2** (rank, observed and percentage			**All other prescribers** (rank, observed and percentage)		
Meropenem	1	14	24.14%	1	6	20.69%	1	8	27.59%
Tazocin	2	11	18.97%	2	5	17.24%	2	6	20.69%
Co-Amoxiclav	2	11	18.97%	2	5	17.24%	2	6	20.69%
Flucloxacillin	4	7	12.07%	4	3	10.34%	4	4	13.79%
Metronidazole	5	5	8.62%	8	1	3.45%	4	4	13.79%
Doxycycline	6	4	6.90%	4	3	10.34%	6	1	3.45%
Clarithromycin	7	2	3.45%	6	2	6.90%	7	0	0.00%
Pyrazinamide	7	2	3.45%	6	2	6.90%	7	0	0.00%
Rifampicin	9	1	1.72%	8	1	3.45%	7	0	0.00%
Rifinah®	9	1	1.72%	8	1	3.45%	7	0	0.00%
Total		58	100%		29	100%		29	100%

DISCUSSION

This is the first study to explore the prescribing behaviour of healthcare professionals, in particular FY doctors, working at a renal unit in the UK. The study confirmed that over the four-month observation period, FY1 doctors were found to make four times, and the FY2 doctors twice, as many errors as the other healthcare professionals. This supports prior research that found FY doctors to make more errors per prescriber than other prescribers.[12] [13] However, without knowing the proportion of prescribing between the groups it is impossible to state categorically the extent of this problem. Nonetheless, the difference in errors observed between the groups supports the suggestion FY doctors would benefit from educational interventions for reducing avoidable harm from medicines tailored to their specific learning needs.[15]

Paracetamol was the medicine most frequently associated with a prescribing error, with FY doctors making proportionally twice as many errors than the other healthcare professionals. Paracetamol was previously found to be one of the five most common incorrect prescriptions in a study exploring the incidence of prescription errors in UK Critical Care units,[21] at a

similar proportion to the other healthcare professionals. This suggests that, proportionally, FY doctors are making far more errors related to Paracetamol than other healthcare professionals. Whilst Paracetamol is freely available over the counter and is often considered to require no subject matter knowledge to prescribe, Paracetamol must be used cautiously in certain patient groups and also needs to be dose adjusted in patients with lower weights. Whilst dosing was related to only 10% of errors in this study, it has previously been found to be as much as 43%.[8] Dornan et al found the notion of safety was inconspicuous by its absence when FY doctors discussed their errors,[13] therefore the lack of safe prescribing behaviours may also explain the observed error rate identified in this study.

Medicines usually associated with kidney disease (Erythropoiesis-stimulating agents, Phosphate binders and Immunosuppression) were involved in a third of all prescribing errors. This suggests two things. First, prescribing in patients with renal disease is challenging, due to the complexity involved[1 2 3 4 5 6 7] irrespective of the clinical experience of the prescriber. Second, patients with renal disease suffer prescribing errors for reasons likely unrelated to the complexity of their condition or a lack of knowledge about renal medicine. Possible explanations for errors made by prescribers may include for example, "slips in attention, memory lapses, the effects of workload and environment, interruptions, hierarchies and poor communication".[23(p455)] Further research is required to establish what individual, social, contextual and environmental factors are present and what educational interventions can be developed to overcome them.

The error types identified in this study confirm that FY doctors and other prescribers are equally prone to making errors related to omission, wrong dosage and using brand names for medicines. This seems a generic problem across all prescribers irrespective of clinical context as confirmed by Taylor et al who reported similar outcomes after an exploration of errors made on handwritten prescription charts in a paediatric emergency department.[24] Comparisons of error type are difficult since there is heterogeneity of coding classification and little standardisation for coding or definitions across studies.

Using the brand name when prescribing medicines is an error in some prescribing contexts. In other contexts not prescribing using brand names can cause significant patient safety issues when prescribing.[25] For example, prescribing using the brand name is a policy requirement for specific transplantation medicines, such as Tacrolimus. In this case inadvertent brand switch could lead to clinically significant negative outcomes such as transplant rejection or drug toxicity. These conflicting guidelines – requiring a brand name in some areas and discouraging it in others – can impact novice prescriber practice as a potential source of error.

Although there may be an issue with conceptualising the use of brand names with prescribing errors, references such as the renal drug handbook and the electronic medicines compendium include clear information and guidance on medication dosing in renal medicine. Despite these information resources being available in the renal unit, wrong dosage was a frequent and consistent problem irrespective of the type of prescriber. This suggests that the problem is related to human factors issues, that can be overcome by further research to identify systemic factors surrounding prescribing.

This study found the majority of prescribing errors to have the potential for minor or significant harm, consistent with prior studies.[13 21] As a proportion of all prescriptions, fewer errors were found (3.54%) in this study compared to more general prescribing contexts. For example, Ridley et al (2004) reported an error rate of 14.55% over a 4-week period in 24

critical care units[21] and Dornan et al (2009) reported 8.91% over seven census data in a study of 19 acute hospital trusts[13]. The wide range in error rate observed in these studies should be the subject of further research. They may reflect differences in prescribing contexts across situations such as: level of prescribing support for healthcare professionals, prescribing experience, and the familiarity with the patient population of the prescriber.

Whilst the clinical supervision of FY doctors from senior medical doctors across a training programme is relatively well established, the educational input by pharmacists remains relatively unutilised in terms of formal teaching and learning. The nature of renal specific errors suggest context specific knowledge is crucial to reduce severe and lethal errors. Pharmacist led interventions are known to add significant value in terms of prescribing error reduction among FY doctors and could do so in specialist contexts.[26] Furthermore, clinical pharmacists are already used in undergraduate education,[27] so extending their role across the continuum of medical education formally, may be one cost-effective strategy for reducing avoidable harm in complex clinical settings such as the renal unit. Further research is necessary to establish the feasibility of using pharmacists for delivering medical education, given the significant pressures clinical pharmacy services face. Nevertheless, given the consistency of findings suggesting FY doctors are error prone, the continued patient safety risk as a result of prescribing errors in complex settings may warrant additional resource.

There are two main limitations to this research. First, sub-group analysis between professional groups was not possible, as the total number of prescriptions made by each prescribing group was not known. Whilst prescription errors by individual medicine name was known for each prescriber, the total number of prescriptions for each medicine was unknown so calculating relative risk by medicine name is not possible. Without this information, this study was unable to establish whether the error rate of FY doctors in relation to the proportion of prescriptions written is higher than other prescribers, or to ascertain which medicines is associated with the highest rate of prescribing errors.

Second, the design of the study was limited to a time period corresponding to a single rotation of doctors and a single centre where handwritten drug charts were used for prescribing medication. Whereas, hospitals are increasingly adopting computerised systems to support prescribing. Whilst these systems reduce the potential for adverse medicine events,[28] particularly in outpatient settings for patients with CKD, they are not error free and have not always been subject to rigorous evaluation.[29] For example, it is mainly the minor and significant errors identified in this research which would be eradicated through electronic prescribing. However, timesaving workarounds could be used to continue to omit information, depending on how well the systems are designed. The renal specific errors are unlikely to be eradicated and should be considered in the design of future computerised systems. In addition, electronic prescribing is not always feasible in all parts of hospitals, e.g. in emergencies, in theatre recovery and in intensive treatment units (ITU). Given that electronic prescribing is becoming more widely adopted, further research will be required into its effects on the type of medicines involved in prescribing errors, the nature of prescribing errors when using these electronic prescribing systems, and the implications this has on the targeting of education and human factors interventions.

All final year medical students in the UK are now expected to successfully complete the Prescribing Skills Assessment in order to progress into the Foundation Programme.[30] Whilst this assessment is a measure of basic level competence upon entry into the workplace; there are no further assessments thereafter. So the actual real world prescribing

performance of FY doctors remains relatively un-scrutinised after medical school. Although formal assessments may be impractical in the postgraduate setting, workplace based assessments around prescribing are established and could be more extensively used with FY doctors to ensure they have the knowledge, skills and attitudes required for safe prescribing.

The differences in prescribing errors between professional groups in this study suggest targeted practice-based education for FY doctors is necessary to improve prescribing performance especially in complex settings like a renal unit. Furthermore, the educational role of clinical pharmacy should be developed given they have significant specialty-specific domain knowledge and currently have limited input into postgraduate medical education. Although the role of the pharmacist is well established in the context of medicines reconciliation, a larger multi-site and multi-context study is needed to evaluate the effectiveness of pharmacist-led education for FY doctors in complex clinical areas.

The disproportionately high frequency of prescribing errors made by FY doctors compared to the senior healthcare professionals is consistent with the findings from previous studies. The proportion of errors per prescriber appears to reflect the clinical experience of the prescriber, suggesting educational interventions should focus on developing prescribing competence rather than increasing subject or domain specific knowledge. Any education-intervention must also encompass vigilance of human factors issues given the prevalence of errors that are caused by situational and systematic factors. Although a third of prescribing errors were associated with medicines specifically prescribed for patients with kidney disease, two-thirds related to generic or commonly prescribed medicines such as Paracetamol. These common errors were similar for FY doctors as well as other prescribers so the findings have implications for the development of renal-specific prescribing education as well as prescribing education in general. Nevertheless, FY doctors specifically make prescribing errors that are potentially significant for patients in a renal unit setting compared to other areas. Therefore, educational interventions should be rooted in practice-based settings where pharmacists are present and already play important roles in medicines safety on the ward. A standardised system for categorising prescribing errors must be adopted to enable comparisons across interventions.

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