

Prescribing errors in hospital inpatients: their incidence and clinical significance

B Dean, M Schachter, C Vincent, N Barber

Qual Saf Health Care 2002;11:340–344

See end of article for authors' affiliations

Correspondence to:
Dr B Dean, Director,
Academic Pharmacy Unit,
Pharmacy Department,
Hammersmith Hospitals
NHS Trust, London W12
0HS, UK; bdean@hhnt.org

Accepted for publication
20 April 2002

Background: It has been estimated that 1–2% of US inpatients are harmed by medication errors, the majority of which are errors in prescribing. The UK Department of Health has recommended that serious errors in the use of prescribed drugs should be reduced by 40% by 2005; however, little is known about the current incidence of prescribing errors in the UK. This pilot study sought to investigate their incidence in one UK hospital.

Methods: Pharmacists prospectively recorded details of all prescribing errors identified in non-obstetric inpatients during a 4 week period. The number of medication orders written was estimated from a 1 in 5 sample of inpatients. Potential clinical significance was assessed by a pharmacist and a clinical pharmacologist.

Results: About 36 200 medication orders were written during the study period, and a prescribing error was identified in 1.5% (95% confidence interval (CI) 1.4 to 1.6). A potentially serious error occurred in 0.4% (95% CI 0.3 to 0.5). Most of the errors (54%) were associated with choice of dose. Error rates were significantly different for different stages of patient stay ($p < 0.0001$) with a higher error rate for medication orders written during the inpatient stay than for those written on admission or discharge. While the majority of all errors (61%) originated in medication order writing, most serious errors (58%) originated in the prescribing decision.

Conclusions: There were about 135 prescribing errors identified each week, of which 34 were potentially serious. Knowing where and when errors are most likely to occur will be helpful in designing initiatives to reduce them. The methods developed could be used to evaluate such initiatives.

There is growing concern over the frequency with which patients are harmed by medical error; major policy documents on this problem have recently been published in both the UK¹ and the US.² Medication errors are one of the most common types of medical error.³ It has been estimated that 1–2% of patients admitted to US hospitals are harmed as a result of medication errors,⁴ the majority of which are errors in prescribing.^{5,6}

In the UK a recent Department of Health report recommended that serious errors in the use of prescribed drugs should be reduced by 40% by 2005.¹ In order to achieve this goal we need to know the current frequency with which errors occur, which types are most common, and which are potentially serious. Even more recently, a report from the UK Audit Commission⁷ further emphasised the problem of medication errors in UK hospitals and highlighted the importance of hospital pharmacists in preventing them. We know that US pharmacists identify and prevent prescribing errors in 0.3–1.9% of all inpatient medication orders written.^{8–11} We have no idea of the equivalent figure for the UK where very different systems are used for the prescription and administration of medication. Studies of pharmacists' interventions have been carried out in UK hospitals^{12–14} but interventions are made for many reasons other than in response to prescribing errors. This paper describes a pilot study of the incidence, types, and clinical significance of prescribing errors in a UK hospital. Our objectives were to estimate the incidence of prescribing errors in inpatients in this hospital, to describe the stages of the inpatient stay in which they happen, to explore where in the prescribing process they occur, and to evaluate their clinical significance.

METHODS

Setting

The study was performed in a 550 bed teaching hospital operating a typical UK ward pharmacy service. Briefly, this

involved prescribers hand writing inpatient medication orders onto a formatted drug chart; this same document was used by nursing staff to determine the doses due at each medication round and to record their administration. Ward pharmacists routinely examined drug charts each weekday to initiate the supply of any drugs not stocked on the ward and to check that all medication orders were clear, legal, and clinically appropriate. At the study hospital any prescribing errors identified were dealt with in one of two ways: (1) if medication orders were ambiguous but the pharmacist could determine the medication intended, he or she would endorse the drug chart accordingly; (2) if the pharmacist was not certain of the medication intended or if the error concerned more fundamental errors in the choice of drug or dose, the prescriber would be contacted to resolve the issue.

The study took place during a 4 week period from mid-June to mid-July 1999 and, in line with many other studies of adverse events, included all non-obstetric inpatients. Prescribers were unaware of the study in order to avoid changes in behaviour. Ethics committee approval was obtained.

Definitions

We had previously developed a definition of a prescribing error using the Delphi technique.¹⁵ Accordingly, a clinically meaningful prescribing error was defined as a prescribing decision or prescription writing process that results in an unintentional, significant reduction in the probability of treatment being timely and effective or increase in the risk of harm, when compared with generally accepted practice. Prescribing without taking into account the patient's clinical status, failure to communicate essential information, and transcription errors were all considered prescribing errors. However, failures to adhere to standards such as national guidelines or the

Table 1 Estimated numbers of medication orders written for the study population

Type of medication order	No (%)
Inpatient medication orders written on admission	11485 (32%)
Inpatient medication orders written during remainder of patient stay	15756 (44%)
Medication orders rewritten onto new inpatient drug charts	3620 (10%)
Medication orders for discharge medication	5307 (15%)
Total	36168 (100%)

drug’s product licence were not considered errors if this reflected accepted practice.¹⁵

Identification and classification of prescribing errors

Prescribing errors were identified by the 25 ward pharmacists at the study hospital as part of their routine prescription monitoring duties. The pharmacists were given two training sessions during which the study methods and definitions were described in detail. Prescribing errors were included if they met the study definition, regardless of how the pharmacist resolved them. As well as a description of the error itself, pharmacists were asked to record details of where the error was identified (on the wards or in the pharmacy department), the grade of prescriber responsible, the stage of patient stay involved (patient admission, remainder of inpatient stay, transcription of a new inpatient drug chart, or discharge), and the components of the prescribing process (need for drug, select specific drug, select dose, give administration instructions, and provide instructions for supply) in which the error occurred. This latter classification system was adapted from the stages of the drug use process.¹² Using their judgement and any conversation held with the prescriber to rectify the error, pharmacists were also asked to indicate whether they believed the error to originate in the prescribing decision or in the prescription writing process; this classification was then checked by one of the investigators (BD).

Clinical significance

One of the investigators (BD) grouped similar errors together and classified each group as either “potentially serious” or “not serious”. A senior clinical pharmacologist (MS) reviewed these classifications independently. The two then met and resolved any disagreements together.

Calculating the number of medication orders written

To obtain a suitable denominator with which to calculate the error rate, it was necessary to estimate the number of medication orders written during the study period. It was estimated that 2910 non-obstetric hospital episodes¹⁶ would fall wholly or partially within the data collection period. A sample of 339 non-obstetric episodes was required to estimate

the number of medication orders written during the study period using a precision of ±5% and a confidence interval of 95%.¹⁷ This is approximately a 1 in 9 sample. However, since it was convenient to sample according to the last digit of the hospital number, the sample was eventually larger, comprising 1 in 5 patients. Patients were allocated hospital numbers sequentially on first referral to the hospital, so this method was unlikely to result in systematic bias.

Four methods were used to identify the patients in the sample:

- (1) All discharge prescriptions dispensed in the main pharmacy were examined daily.
- (2) A patient administration system (PAS) report was produced daily showing the previous day’s discharges. This allowed any patients discharged without medication to be identified.
- (3) A report was obtained of all inpatients remaining in the hospital at the end of the study period.
- (4) A PAS report was produced after the study’s completion to identify any additional patients whose discharge, death, or transfer had been entered retrospectively.

The medical notes for each non-obstetric patient in the sample were retrieved and all medication orders dated during the study period counted. “Once only” and “when required” medication and intravenous fluids were included; medication prescribed only on anaesthetic charts was excluded, as were blood products and oxygen. Where discharge medication orders were written but not dispensed—for example, because patients had their own supplies of medication—these were included. As with prescribing errors, medication orders were classified as being written on a patient’s admission, during the remainder of the patient’s stay, during the transcription of a new inpatient drug chart, or at discharge.

Data analysis

The number of medication orders written during the study period for the whole study population was estimated and the percentage containing a prescribing error was calculated together with its confidence interval.¹⁸ Each medication order could be associated with only one prescribing error. Separate prescribing error rates were calculated for medication orders written at each stage of patient stay and a χ^2 test used to test the null hypothesis that these error rates were the same. Both serious and less serious errors were classified according to stage of patient stay, components of the prescribing process, and whether they originated in the prescribing decision or in the prescription writing process. χ^2 tests were again used to test the null hypotheses that the distributions of serious and less serious errors were the same.

RESULTS

Medication orders written

There were 459 hospital episodes in the 1 in 5 sample; the medical notes were retrieved for 445 of these (97%). For these

Table 2 Prescribing errors according to stage of patient stay, expressed as percentages of the number of medication orders of that type

Stage of patient stay	No of medication orders	Serious errors	Other errors	Total errors
Inpatient medication orders written on admission	11485	28 (0.3%)	119 (1.0%)	147 (1.3%)
Inpatient medication orders written during remainder of patient stay	15756	83 (0.5%)	198 (1.3%)	281 (1.8%)
Medication orders rewritten onto new inpatient drug charts	3620	13 (0.4%)	23 (0.6%)	36 (1.0%)
Medication orders for discharge medication	5307	17 (0.3%)	52 (1.0%)	69 (1.3%)
Unknown	0	1	4	5
Total	36168	142 (0.4%)	396 (1.1%)	538 (1.5%)

Table 3 Serious errors and other errors categorised according to components of the prescribing process

Component of prescribing process	Serious errors	Other errors	Total
Need for drug therapy	47 (33%)	49 (12%)	96 (18%)
Select specific drug	12 (8%)	21 (5%)	33 (6%)
Select drug dose	78 (55%)	211 (53%)	289 (54%)
Give administration instructions	5 (4%)	46 (12%)	51 (9%)
Give instructions for supply of product	0	69 (17%)	69 (13%)
TOTAL	142 (100%)	396 (100%)	538 (100%)

episodes a total of 7013 medication orders were written during the study period, so it can be estimated that 36 168 medication orders were written for the entire population during this period (table 1), equivalent to nearly 1300 per day. The mean number of medication orders written during the study period for each hospital episode was 15.8 (95% CI 14.4 to 17.1).¹⁷

Prescribing errors identified

Pharmacists reported 651 incidents; however, 113 related to advice giving and formulary issues and did not meet the study's definition of a prescribing error. A total of 538 prescribing errors were therefore included, giving an overall prescribing error rate of 1.5% (95% CI 1.4 to 1.6). Of these, 90% were identified on the wards, the remainder in the pharmacy department. The grade of the prescriber was recorded for 482 (90%) of the prescribing errors; 10 (2%) were prescribed by consultants, 46 (10%) by registrars, 269 (56%) by senior house officers, and 157 (33%) by junior house officers. The drugs most commonly involved were paracetamol (34 errors), morphine (21), diamorphine (18), metoclopramide (18), and beclomethasone (16).

Table 2 presents the errors according to stage of patient stay; overall error rates for each stage of patient stay were different ($p < 0.0001$; χ^2 test) with the highest error rates identified for new medication orders written during the inpatient stay. Table 3 shows the errors according to the components of the prescribing process. According to the pharmacists' assessments, 39% of the prescribing errors originated in the prescribing decision and 61% in medication order writing.

There were large differences between wards and pharmacists in terms of the numbers of errors identified with the highest numbers of errors being identified on the vascular surgery, renal, infectious diseases and intensive care wards.

Clinical significance

It was concluded that 142 errors (26%) were potentially serious, equivalent to 0.4% of all medication orders written (95% CI 0.3 to 0.5). Examples of potentially serious and less serious errors are given in table 4. Many of the potentially serious errors would be expected to have resulted in significant patient harm had they not been intercepted. There were less dramatic differences between pharmacists in terms of the numbers of serious errors reported.

When analysed according to stage of patient stay (table 2), the distribution of serious errors is not significantly different from that for other errors ($p = 0.06$; χ^2 test). However, when classified according to the components of the prescribing process (table 3), the distribution of serious errors is significantly different from that for other errors ($p < 0.0001$; χ^2 test) with a higher proportion of serious errors occurring in the components of identifying the need for drug treatment and selecting the drug dose.

When only the serious errors were examined, 58% originated in the prescribing decision and 42% in medication order writing. This is a different distribution from that for non-serious errors in which the majority (68%) occurred in medication order writing ($p < 0.0001$; χ^2 test).

DISCUSSION

Incidence and types of prescribing errors

Pharmacists identified and rectified a prescribing error in 1.5% of all medication orders written, of which about one quarter were potentially serious and likely to result in patient harm. All were identified by the routine hospital pharmacy service. These figures are comparable to those quoted in US studies,⁸⁻¹¹ although there may be some differences in the definitions of an error used.

Table 4 Examples of errors identified

Potentially serious prescribing errors	Less serious prescribing errors
An elderly patient was prescribed 10 ml IV diazepam (equivalent to 50 mg) to be given when required, instead of the intended 10 mg.	A patient already taking lansoprazole 30 mg daily was additionally prescribed ranitidine 150 mg twice daily.
Captopril 250 mg twice daily was prescribed when 25 mg twice daily was intended.	Beclomethasone inhaler was prescribed without specifying the intended strength (100 µg per inhalation).
A patient had a phenytoin level of 5.5 mg/l on a dose of 350 mg daily. The dose was erroneously reduced to 120 mg daily.	A patient was prescribed 20 mg lansoprazole daily when 30 mg was intended. Capsules are available only as 15 mg or 30 mg strengths.
A patient was prescribed metoclopramide 10 mg 8 hourly on each of his 3 drug charts, resulting in the patient receiving 90 mg daily until the pharmacist intervened.	Isosorbide dinitrate was prescribed instead of isosorbide mononitrate.
Intravenous ranitidine 50 mg tds was inadvertently omitted for a critically ill patient with peptic ulcer disease whose drug chart was rewritten.	Glyceryl trinitrate was prescribed without specifying the dose or formulation to be administered.
	Sustained release nifedipine 20 mg daily prescribed when 20 mg twice daily was intended.

In the study hospital an average of nearly one inpatient medication order was written every minute. If we assume that most prescribing takes place between 08.00 and 18.00 hours, Mondays to Fridays, then one inpatient medication order is written about every 20 seconds. It is not surprising that this act is sometimes accompanied by error. In this hospital there were about five potentially serious errors every day. This is not acceptable, particularly as two of these arose in writing medication orders on admission or discharge, or rewriting new drug charts—tasks which are based mainly on transcription.

Most of the prescribing errors were made by the more junior medical staff. However, these are the staff responsible for the majority of prescribing in hospital inpatients and it is not possible to draw conclusions about the grades of prescriber most likely to make errors. We initially attempted to measure the frequency of prescribing by each grade of staff but it proved impossible to identify many of the prescribers from their signatures.

It was found that the highest rates of both serious and less serious errors were for medication orders written during patients' stay (overall error rate 1.8%; serious error rate 0.5%). However, it is also of concern that rewriting inpatient drug charts and writing discharge prescriptions—tasks based mainly on transcription—were associated with an overall error rate of at least 1% and a serious error rate of at least 0.3%.

In terms of the components of the prescribing process, most of the errors concerned selection of the drug dose. This was also found to be the case in previous US studies.^{6 8 10 11} Potentially serious errors occurred mainly in deciding whether or not drug treatment is required and in selection of the drug dose. Although the majority of all errors were judged to originate in medication order writing, most of the serious errors were considered to originate in the prescribing decision.

We also found that error rates varied greatly between wards. The extent to which this reflects differences in prescribing error rates, prescribing volume, or pharmacists' data collection, experience or grade is unknown. A previous study suggests that ward type, amount of time spent on the ward, and pharmacist grade all affect the number of clinical interventions made.¹³

Reflections on the methodology

The errors reported here were all identified and rectified by pharmacists. Other studies of adverse events in hospital inpatients have used reviews based on medical notes and have focused on those errors that resulted in patient harm.^{3 5 6 10} We do not know whether the errors that result in patient harm differ substantially from those that are identified before harm can result. The main advantage of our method is that pharmacists routinely see all drug charts and all patients each week-day, as well as being part of the multidisciplinary team at the time of the patient's treatment. They will therefore be seeing and talking to the patient and the medical team and will have more information about each patient available to them than to those retrospectively reviewing the medical notes. The main disadvantage is that pressure of workload means that there may be under-reporting and variation between pharmacists in terms of their data collection. Unfortunately, we do not know how many errors were not detected or how many were detected but not reported. Further work is needed to establish the reliability of the identification and documentation of prescribing errors by pharmacists.

Although targets such as those set by the UK Department of Health¹ focus on serious errors, there is relevance in studying all errors. Many types of error may be unlikely to result in harm in one drug or patient but may be more serious in another. However, our simple assessment of risk should be enhanced in future studies by recording whether or not the

Key messages

- Nearly 10 000 medication orders were written each week during the 4 week study period.
- A prescribing error occurred in at least 1.5% of these, of which a quarter were potentially serious.
- All the errors were identified by hospital pharmacists and drawn to the prescriber's attention.
- Most of the errors related to the choice of drug dose.
- The methods used in this pilot study could be used in a larger study to evaluate the impact of initiatives to reduce prescribing errors and their consequences, and could be used for routine error monitoring in hospitals.

patient received the drug before the error was corrected, together with a more robust assessment of severity.²⁰ Further work is also needed to establish the validity of the methods used to classify errors as originating in the prescribing decision or in the prescription writing process.

The study hospital was a teaching hospital; we do not know how this is likely to have affected the results. One study of interventions by UK pharmacists suggests that bed mix is an important predictor of the intervention rate.¹³ Since this is likely to be different between teaching and non-teaching hospitals, and between one hospital and another, the findings may have been quite different in another setting. The time period studied was towards the end of a junior medical staff rotation; we do not know how the error rate may have differed had the study taken place at the beginning of a new rotation.

Recommendations

Our method used the pharmacy service that exists in nearly all hospitals²¹ and therefore has the potential to be widely applied. It is ironic that this study is the first in the UK of its type, while merely formalising existing services conducted by the ward pharmacist. It is one example of useful data not being routinely used to help reduce errors. One of us previously started an annual survey of interventions by hospital pharmacists, many of which were related to prescribing errors,^{13 14} and suggested that these findings could be incorporated into a regular monitoring and feedback system.²² At present, pharmacists routinely intercept errors but only give the feedback to the prescriber. While preventing and correcting errors, this has two problems: (1) errors are not shared across the team²³ and (2) this does not enable us to study hospital-wide and national issues nor to develop strategies for their reduction. The recent focus on errors by the UK Department of Health,¹ the US Institute of Medicine,² and the UK Audit Commission⁷ means that now may be an appropriate time to revisit these ideas.

Taking the results as a whole, prescribers need to take heed of the need for a drug, choosing the dose, and of any acts of transcribing. The role that pharmacists play in the detection and correction of error needs to have greater recognition and to be formalised into a routine monitoring and feedback system. However, pharmacists are unable to prevent all errors due to time delays between prescribing and their seeing the drug chart, and because of limitations in the experience, knowledge, and workload of individual pharmacists. The impact of changes to pharmacy services or interventions such as the introduction of computerised prescribing could be measured using similar methodology to that used in this study. A study of the causes of some of the prescribing errors identified in this study has been published elsewhere.²⁴

ACKNOWLEDGEMENTS

The authors would like to acknowledge the help of all pharmacy staff in the study hospital, and the London Regional Specialist Pharmacy Services for their help and advice.

.....
Authors' affiliations

B Dean, Research Pharmacist, Department of Practice and Policy, The School of Pharmacy, University of London, London WC1N 1AX, UK
M Schachter, Senior Lecturer and Honorary Consultant Physician, Clinical Pharmacology, Imperial College School of Medicine, London, UK
C Vincent, Professor of Psychology, Clinical Risk Unit, University College London, London WC1E 6BT, UK
N Barber, Professor of the Practice of Pharmacy, Department of Practice and Policy, The School of Pharmacy, University of London, London WC1N 1AX, UK

This research was funded by the NHS Executive London (NHSE-LRO) Research and Development Responsive Funding Programme. The views and opinions expressed do not necessarily reflect those of the NHSE-LRO nor the Department of Health.

REFERENCES

- 1 **Department of Health**. *An organisation with a memory*. Report of an Expert Group on Learning from Adverse Events in the NHS. London: The Stationery Office, 2000.
- 2 **Institute of Medicine**. *To err is human: building a safer health system*. Report of the Committee on Quality of Health Care in America. Washington: National Academy Press, 2000.
- 3 **Leape LL**, Brennan TA, Laird N, et al. The nature of adverse events in hospitalized patients. Results of the Harvard medical practice study II. *N Engl J Med* 1991;**324**:377-84.
- 4 **Barber ND**, Dean BS. The incidence of medication errors and ways to reduce them. *Clinical Risk* 1998;**4**:103-6.
- 5 **Leape LL**, Bates DW, Cullen DJ, et al. Systems analysis of adverse drug events. *JAMA* 1995;**274**:35-43.
- 6 **Bates DW**, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events: Implications for prevention. *JAMA* 1995;**274**:29-34.
- 7 **The Audit Commission**. *A spoonful of sugar: medicines management in NHS hospitals*. Wetherby: Audit Commission Publications, 2001.
- 8 **Lesar TS**, Briceland LL, Delcours K, et al. Medication prescribing errors in a teaching hospital. *JAMA* 1990;**263**:2329-34.
- 9 **Lesar TS**, Briceland L, Stein DS. Factors related to errors in medication prescribing. *JAMA* 1997;**277**:312-7.
- 10 **Blum KV**, Abel SR, Urbanski CJ, et al. Medication error prevention by pharmacists. *Am J Hosp Pharm* 1988;**45**:1902-3.
- 11 **Folli HL**, Poole RL, Benitz WE, et al. Medication error prevention by clinical pharmacists in two children's hospitals. *Pediatrics* 1987;**79**:718-22.
- 12 **Cousins D**, Hatoum H. The development of a computerised quality assurance system for clinical pharmacy. *Int J Pharmacy Pract* 1991;**1**:86-9.
- 13 **Barber ND**, Batty R, Ridout DA. Predicting the rate of physician-accepted interventions by hospital pharmacists in the United Kingdom. *Am J Health-Syst Pharm* 1997;**54**:397-405.
- 14 **Batty R**, Barber N. Ward pharmacy: a foundation for prescribing audit? *Qual Health Care* 1992;**1**:5-9.
- 15 **Dean B**, Barber N, Schachter M. What is a prescribing error? *Qual Health Care* 2000;**9**:232-7.
- 16 **Hornbrook MC**, Hurtado AV, Johnson RE. Health care episodes: definition, measurement and use. *Med Care Rev* 1985;**42**:163-218.
- 17 **Wonnacott TH**, Wonnacott RJ. *Introductory statistics for business and economics*. New York: John Wiley and Sons, 1990.
- 18 **Gardner MJ**, Altman DG. *Statistics with confidence: confidence intervals and statistical guidelines*. London: BMJ Publications, 1989.
- 19 **Vincent C**, Neale G, Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. *BMJ* 2001;**322**:517-9.
- 20 **Dean BS**, Barber ND. A validated, reliable method of scoring the severity of medication errors. *Am J Health-Syst Pharm* 1999;**56**:57-62.
- 21 **Cotter SM**, Barber ND, McKee M. Survey of clinical pharmacy services in United Kingdom National Health Service hospitals. *Am J Hosp Pharm* 1994;**51**:2676-84.
- 22 **Barber ND**. Improving quality of drug use through hospital directorates. *Qual Health Care* 1993;**2**:3-4.
- 23 **Dean B**. Learning from prescribing errors. *Qual Saf Health Care* 2002;**11**:258-60.
- 24 **Dean B**, Schachter M, Vincent C, et al. Causes of prescribing errors in hospital inpatients: a prospective study. *Lancet* 2002;**359**: 1373-8.