Hospital prescribing errors: epidemiological assessment of predictors

R. Fijn,[1] P. M. L. A. Van den Bemt,[2,3] M. Chow,[1] C. J. De Blaey,[4,5] L. T. W. De Jong-Van den Berg[1] & J. R. B. J. Brouwers[1,2]

[1]*Groningen University Institute for Drug Exploration (GUIDE), University of Groningen, Division of Pharmacoepidemiology and Drug Policy, Department of Social Pharmacy and Pharmacoepidemiology, Groningen,* [2]*General Hospital De Tjongerschans, Department of Hospital Pharmacy and Clinical Pharmacology, Heerenveen,* [3]*Leeuwarden Medical Centre, Department of Hospital Pharmacy and Clinical Pharmacology, Leeuwarden,* [4]*Scientific Institute Dutch Pharmacists, Royal Dutch Society for the Advancement of Pharmacy, The Hague, and* [5]*Utrecht Institute for Pharmaceutical Studies (UIPS), Utrecht University, Department of Pharmacotherapy and Pharmacoepidemiology, Utrecht, The Netherlands*

Aims To demonstrate an epidemiological method to assess predictors of prescribing errors.

Methods A retrospective case-control study, comparing prescriptions with and without errors.

Results Only prescriber and drug characteristics were associated with errors. Prescriber characteristics were medical specialty (e.g. orthopaedics: OR: 3.4, 95% CI 2.1, 5.4) and prescriber status (e.g. verbal orders transcribed by nursing staff: OR: 2.5, 95% CI 1.8, 3.6). Drug characteristics were dosage form (e.g. inhalation devices: OR: 4.1, 95% CI 2.6, 6.6), therapeutic area (e.g. gastrointestinal tract: OR: 1.7, 95% CI 1.2, 2.4) and continuation of preadmission treatment (Yes: OR: 1.7, 95% CI 1.3, 2.3).

Conclusions Other hospitals could use our epidemiological framework to identify their own error predictors. Our findings suggest a focus on specific prescribers, dosage forms and therapeutic areas. We also found that prescriptions originating from general practitioners involved errors and therefore, these should be checked when patients are hospitalized.

Keywords: hospital prescribing errors, pharmacoepidemiology, predictors

Introduction

Hospitalized patients are exposed to multiple drug treatment often involving potentially harmful drugs [1, 2]. Many prescribed drugs are part of treatment that has originally been initiated by general practitioners. Prescriptions for these drugs are often continued without knowledge about the relevance or potential hazards of polypharmacy [3, 4]. The number of drugs marketed is substantial and superspecialization of clinicians is increasing. Consequently, clinicians' knowledge and clinical experience with prescribed drugs is declining. Potential drug related problems for hospitalized patients are therefore a cause of international concern [2, 5].

Drug related problems are classified into two categories: medication errors (MEs) and adverse drug effects (ADEs) [2, 8]. MEs occur at five levels: drug selection, prescribing, dispensing, administration, and therapeutic monitoring. ADEs include unintended clinical effects after administration. Drug related problems can result in decreased quality of life, morbidity or mortality. Prevention is thus important. In the Netherlands, clinicians are responsible for preventing MEs in drug selection and for dealing with ADEs. Pharmacists are responsible for dispensing and therapeutic monitoring. Prescribing and administration are joint responsibilities. This situation differs in other countries [6, 7].

The objective of this study was to explore an epidemiological framework to assess predictors of prescribing errors, considering patient, prescriber and drug characteristics.

Correspondence: Dr R. Fijn, Medical Sciences and Pharmacy, Social Pharmacy and Pharmacoepidemiology, Antonius Deusinglaan 1, 9713 AV Groningen, The Netherlands. Tel: +31 503637576; Fax: +31 3632772. E-mail: R.Fijn@apoth.azg.nl

Received 20 December 2000, accepted 19 November 2001.

Methods

Design and data collection

A retrospective explorative case-control study (approximately 1 : 3) was performed. In two teaching hospitals,

during 14 consecutive days, all new prescriptions issued for hospitalized patients were collected. Repeat prescriptions were excluded. Based on a power calculation including a randomly chosen potential predictor (desired odds ratio $0.8 < OR > 1.2$, $P < 0.05$), random samples of cases (prescriptions with one or multiple errors) ($n = 449$) and controls (prescriptions without errors) ($n = 1464$) were drawn from a source of 5302 prescriptions (of which 14% with errors and 86% without errors). The total of 1913 prescriptions was used for further analysis.

Outcome measures

Prescribing errors were categorized based on the literature: administrative and procedural errors, dosing errors, and therapeutic errors [9–15]. Therapeutic errors specifically concerning irrational drug treatment regarding a certain indication, involve MEs at the level of drug selection and fall outside the scope of this study.

Errors were independently identified and categorized by two raters based on the hospitals' prescribing policies and the drugs' official patient leaflets: a hospital pharmacist (PvdB) and a clinical pharmacologist (JB).

Exposure measures

Potential predictors of errors included (a) prescriber characteristics (medical specialty; prescriber status: clinician staff, assistant clinician, verbal orders transcribed by nursing staff; prescribing day, prescription lay-out: full medication chart overview or single drug prescription; number of daily prescribed drugs per prescriber; hospital size), (b) patient characteristics (sex; age; number of coprescriptions), and (c) drug characteristics (dosage form; therapeutic area: identified by Anatomical-Chemical-Therapeutic (ATC) code; continuation of preadmission treatment: Yes or No; formulary inclusion: Yes or No; drug age: calculated by the year of introduction to the market; numbers of similar marketed drugs and included in the formulary; formulary restrictiveness: expressed by the percentage of similar marketed drugs that is included in the formulary).

Analysis

We performed a univariable ($P < 0.05$) and multivariable logistic regression analysis based on a conditional stepwise forward logistic regression model ($P < 0.01$), using SPSS® 9.0. Crude and adjusted ORs with 95% confidence intervals (95%CI) were calculated. Analysis was performed for overall errors and subsequently, for each subcategory as main outcome measure.

Results

For error identification within subcategories, a kappa of 0.74, 0.90, and 0.83, respectively, was calculated as a measure of agreement between the two raters [16]. As the pharmacist was most closely involved in routine prescribing audit, her classification was eventually used. Table 1 presents detailed information on all prescriptions with one or multiple errors ($n = 449$) that were included in this study and subcategorized into administrative and procedural errors, dosing errors and/or therapeutic errors.

The top three therapeutic areas involved in errors were the central nervous system, the gastrointestinal tract, and the respiratory tract. Prescriptions for drugs acting in these areas accounted for 25% (114/449), 20% (92/449) and 12% (53/449), respectively. The distribution within the top three therapeutic areas involved was similar across the three subcategories of errors. However, with respect to dosing and therapeutic errors, third position was replaced by cardiovascular and infectious diseases, respectively.

Table 2 presents the findings of the multivariable analysis. Across all error subcategories, only prescriber and drug characteristics were associated with errors. After univariable analysis, the number of drugs prescribed daily per prescriber and the weekday of prescribing appeared predictors of errors. However, after multivariable analysis, associations disappeared. Patient characteristics were not associated with errors. Whether the prescribed drug was included in the hospital formulary, the numbers of similar drugs included in the formulary and marketed, the degree of formulary restrictiveness per drug group and the time elapsed since the drug was introduced, were not predictors of errors.

Conclusions

Our findings suggest that protection of hospitalized patients against prescribing errors requires a focus on prescriptions taking account of certain prescribers, dosage forms, and therapeutic areas. Many errors involve continued prescriptions initiated in general practice. The need for improved communication regarding prescribed drugs is obvious. Our findings refer to the participating hospitals only. Nevertheless, they are in line with other studies [9, 11, 14, 18–20, 23]. However, differences between hospitals, regions and countries are inevitable and the epidemiological framework presented here could be used to explore predictors in other hospitals.

A strength of this explorative study is the directness of the epidemiological method including different kinds of predictors and comparing erroneous with non-erroneous prescriptions. This approach has not previously been validated in European settings. Prescribers' unawareness of the study is expected to have reduced potential

Table 1 Hospital prescriptions with errors ($n = 449$).

Subcategory	n	*(%) of all prescriptions with errors (n = 449)†*	*Examples*
Administrative and procedural errors	245	(55)	
General level			
Unreadable prescription	14	(3)	Obvious
Prescription date or start date unclear	25	(6)	Obvious
Non-drug information on the prescription	2	(<1)	'Patient was asleep at 1.00 a.m.'
Patient level			
Patient data incomplete/unclear	4	(1)	Patient identification impossible
Patient mix-up	1	(<1)	Obvious
Non-existing patient	5	(1)	Patient already discharged or deceased
Prescriber level			
Prescriber data missing/unclear	7	(2)	Department identification impossible
Department mix-up	11	(2)	Patient moved to other department
Prescriber signature missing/unclear‡	64	(14)	Obvious
Drug level			
Drug name missing/unclear	20	(5)	'Atoratin': instead of Atorvastatin
Drug name mix-up	5	(1)	'Phenytoin' instead of Phenylephrine
Unauthorized abbreviation	8	(2)	'TCA': trichloric acid or triamcinolon acetonide?
Amount of drug missing/unclear	13	(3)	'Tretinoin cremor': 20 g or 5 g?
Administration level			
Dosage form missing/unclear or mix-up	33	(7)	'Salbutamol inhaler': rotacaps, rotadisk or aerosol?
Non-existing dosage form	15	(3)	'Diclofenac inhaler'
Route missing/unclear or mix-up	26	(6)	'Pilocarpin 2 dd 2 dr': which eye(s)?
Dosing errors	282	(63)	
Non-existing strength	18	(4)	'Ondansetron 50 mg'
Strength missing/unclear	41	(9)	'Levothyroxin 2 dd 1 tablet': 0.25 or 0.125?
Dosing frequency incomplete/unclear	27	(6)	'1 dd 20 mg + 20 mg, but not 40 mg'
Wrong dosing frequency (time schedule)	11	(2)	'Temazepam 20 mg 2 dd 1 (8 + 10 a.m.)'
Overdosing (supratherapeutic)	67	(15)	
Maximum daily dose missing/unclear	48	(11)	'2 ml Pethidin 50 mg ml^{-1}, as needed'
Maximum daily dose exceeded	19	(4)	'Digoxin 0.25 mg' 3 dd 3 tablets
Underdosing (subtherapeutic)	29	(6)	'Flucloxacillin 50 mg' 1 dd 1 capsule
Duration of therapy unclear/exceeded	22	(5)	'Xylometazolin 0.5 mg 3 dd 2 dr for 3 weeks'
Therapeutic errors	58	(13)	
Contra-indication (including allergy)	8	(2)	Cisapride for arrhythmic patient
Drug–Drug interaction	24	(5)	Magnesiumoxide and ferrofumarate coprescribed
Ineffective monotherapy	4	(1)	Flucytosine monotherapy
(Pseudo) Duplicate therapy	22	(5)	Temazepam and oxazepam

†: One prescription may involve multiple errors; ‡: Dutch legal implication that dispensing is prohibited.

underestimation of errors. Potential classification bias is a weakness of our study, although this was minimized by using patient information sheets as a reference to identify errors. Furthermore, we were unable to include the clinical experience of prescribers. However, we used their status to partly account for this.

The reported incidence of prescribing errors varies from 3 to 169 per 1000 prescriptions. These figures depend strongly on study design and particularly, on the definition of 'error' and the clinical relevance [2, 8, 9, 11, 14, 17, 31]. Our findings agree with other studies showing that missing and incorrect doses are the most common errors whereas patient mistakes are rare [11, 14, 18–20]. Our data link with others showing that analgesic, cardiovascular, and gastrointestinal drug groups are most frequently involved [11, 13, 15]. However, they do not support observations indicating that infectiology is a troublesome area [11, 14, 15, 18]. Instead, we identified oncological and topical therapy (dermatological and ophthalmologic), and inhalation devices prescribed by nonpulmonologists as predictors. These involve individual-based dosing or a wide variety of specific dosage forms, implying nonstandardized dosing and the risk of confusion. To our knowledge these potential predictors have not previously been validated.

As for the medical specialties involved, paediatrics, geriatrics, and intensive care medicine are supposed to be

Table 2 Predictors of prescribing errors: Multivariable case-control analysis ($n = 1913$)†.

	Overall errors		Administrative and procedural errors		Dosing errors		Therapeutic errors	
Predictor	OR_{adj}	*95% CI*	OR_{adj}	*95% CI*	OR_{adj}	*95% CI*	OR_{adj}	*95% CI*
Prescriber characteristics								
Medical specialty‡								
Cardiology	NS	–	NS	–	NS	–	NS	–
Geriatrics	NS	–	NS	–	NS	–	NS	–
Gynaecology and obstetrics	1.81	1.11, 3.00	NS	–	3.76	2.27, 6.23	NS	–
Internal medicine	NS	–	2.10	1.42, 3.12	1.84	1.30, 2.59	NS	–
Intensive care medicine	NS	–	NS	–	0.17	0.05, 0.63	NS	–
Neurology	NS	–	NS	–	NS	–	NS	–
Oncology	NS	–	NS	–	NS	–	NS	–
Orthopaedics	3.36	2.08, 5.41	5.30	3.12, 9.04	1.90	1.13, 3.22	NS	–
Paediatrics and neonatology	NS	–	NS	–	NS	–	NS	–
Psychiatry	NS	–	NS	–	NS	–	NS	–
Pulmonology	0.53	0.36, 0.78	NS	–	NS	–	NS	–
Surgery	NS	–	NS	–	1.91	1.24, 2.97	NS	–
Urology	NS	–	NS	–	NS	–	NS	–
Prescriber status								
Clinician staff (Ref)								
Assistant clinician	1.57	1.15, 2.14	NS	–	NS	–	NS	–
Nursing staff ††	2.53	1.77, 3.62	NS	–	3.23	2.19, 4.77	2.60	1.24, 5.45
Total number of prescribed drugs	NS	–	NS	–	NS	–	NS	–
Prescribing day	NS	–	NS	–	NS	–	NS	–
Hospital size								
Large >500 beds (Ref)	1.0	–	1.0	–				
Small ≤ 500 beds	0.73	0.56, 0.95	0.34	0.22, 0.51	NS	–	NS	–
Prescription lay-out:								
Full medication overview (Ref)							1.0	–
Single drug prescription	NS	–	NS	–	NS	–	1.58	1.29, 1.84
Patient characteristics								
Sex	NS	–	NS	–	NS	–	NS	–
Age	NS	–	NS	–	NS	–	NS	–
Total number of coprescriptions	NS	–	NS	–	NS	–	NS	–
Drug characteristics								
Dosage form								
Eye preparations	11.1	4.34, 28.5	4.21	1.44, 12.3	7.57	2.37, 24.1	NS	–
Inhalation devices	4.10	2.55, 6.62	3.15	1.10, 9.00	2.52	1.43, 4.47	NS	–
Topical applicatives	2.41	1.20, 4.85	NS	–	NS	–	NS	–
Oral preparations	NS	–	NS	–	NS	–	NS	–
Parenteral solutions	NS	–	NS	–	NS	–	0.31	0.11, 0.88
Rectal preparations	1.76	1.04, 2.97	NS	–	NS	–	NS	–
Therapeutic area (ATC code)								
Gastrointestinal tract (A)	1.69	1.20, 2.38	NS	–	2.29	1.57, 3.34	NS	–
Blood system (B)	NS	–	NS	–	NS	–	NS	–
Cardiovascular tract (C)	NS	–	NS	–	NS	–	NS	–
Hormonal systemic therapy (H)	NS	–	NS	–	NS	–	NS	–
Infections (J and P)	NS	–	NS	–	NS	–	NS	–
Cancer therapy (L)	2.59	1.03, 6.53	NS	–	3.29	1.13, 5.34	NS	–
Musculo-skeletal system (M)	NS	–	NS	–	NS	–	3.34	1.07, 10.5
Nervous system (N)	1.73	1.26, 2.37	NS	–	1.76	1.20, 2.58	2.33	1.24, 4.40
Respiratory tract (R)	NS	–	3.11	1.20, 8.11	NS	–	NS	–
Other: topical therapy (D, G, S)	NS	–	NS	–	2.64	1.30, 5.34	NS	–
Continued pre-admission drug								
No, hospital initiated (Ref)					1.0	–		
Yes, general practice initiated	1.74	1.33, 2.29	NS	–	1.68	1.23, 2.31	NS	–

Table 2 (Cont.)

Predictor	Overall errors		Administrative and procedural errors		Dosing errors		Therapeutic errors	
	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI	OR_{adj}	95% CI
Drug included in HDF (Yes or No)	NS	–	NS	–	NS	–	NS	–
Drug Age/Year of marketing	NS	–	NS	–	NS	–	NS	–
Number of fellow drugs on the market	NS	–	NS	–	NS	–	NS	–
Number of fellow drugs in the HDF	NS	–	NS	–	NS	–	NS	–
HDF Restrictiveness	NS	–	NS	–	NS	–	NS	–

†: The level of statistical significance was set at $P=0.05$ (χ^2 testing); The multivariable model for each category of errors was constructed by performing stepwise forward logistic regression analysis. Adjustment was done for all possible confounding factors that significantly contributed to the model. Non-significant factors (NS) were not adjusted for. ‡: All other medical specialties as reference. ††: Verbal orders transcribed by nursing staff.

the most frequently involved in errors. However, our findings show that these medical specialties are significantly less associated with errors [11, 14, 15, 18, 19, 21]. Instead, we identified surgery, gynaecology and obstetrics, and orthopaedics. These specialties rarely initiate drug treatment outside their own therapeutic area, and generally, knowledge about and interest in drugs may be poor [15, 28]. However, within paediatrics, geriatrics and intense care medicine, drug treatment is important. Moreover, patients from these specialities are at high risk of drug related problems due to complex pathology, morbidity and pharmacokinetics [18, 19, 21, 22]. Apparently, these considerations are taken into account in our participating hospitals. The reason for internists to be associated with particular dosing errors may relate to their involvement with a wide range of therapeutic areas.

Our data confirm that nursing staff [23, 24], as well as assistant clinicians [11] are associated with errors. Findings that weekday and prescription volume are associated with errors could not be confirmed [11, 23]. Our findings support suggestions to use full medication chart overviews for prescribing. In this way potential drug–drug interactions cannot slip away from the attention of prescribers which is the case when using single drug prescriptions [13]. Dutch hospital formularies provide detailed prescribing information on all (new) drugs included, thereby intending to reduce errors. Our findings suggest that this intention is of a theoretical nature only.

The impact of hospital prescribing on prescribing in general practice is substantial and has been documented [25, 31]. Without adequate information transfer between healthcare professionals at hospital discharge, patients are at risk of exposure to MEs in the case of repeat prescriptions [4, 12]. Conversely, the impact of general practitioners prescribing on hospital prescribing has also been demonstrated [3, 26]. Our findings show that the risk of errors also exists in this opposite direction of crossing the interface between primary and secondary healthcare, on hospital admission. On admission, confusion about current preadmission treatment exists and dosing of preadmission drugs is often continued based on patient memory without further verification at his or her community pharmacy. In due time, in the Netherlands, hospitals will introduce computerized prescribing and electronic pharmacotherapeutic information transfer between sectors [7, 27, 29, 30].

The authors acknowledge the assistance of L.G. Pont, Department of Clinical Pharmacology, University of Groningen, the Netherlands in manuscript preparation. Thanks are also expressed to the pharmacists R.S. Angela, L.D.R. Wever, E. Boerstoel, and the statistician-methodologist H. Tobi PhD, Department of Social Pharmacy and Pharmacoepidemiology, University of Groningen, The Netherlands and all hospital pharmacy staff for their assistance in study design, data collection, and data analysis. This research was initiated and funded by the Scientific Institute Dutch Pharmacists, Royal Dutch Society for the Advancement of Pharmacy, The Hague, the Netherlands.

References

1 Bochner F, Martin ED, Burgess NG, Somogyi AA, Misan GMH. Controversies in treatment. How can hospitals ration drugs? *Br Med J* 1994; **308**: 901–908.
2 Van den Bemt PMLA, Egberts ACG, De Jong-Van den Berg LTW, Brouwers JRBJ. Drug related problems in hospitalised patients. *Drug Saf* 2000; **22**: 321–333.
3 Himmel W, Lönker B, Kochen MM. Nonformulary drug requests at an academic hospital in Germany – the role of general practitioners' long-term medication. *Eur J Clin Pharmacol* 1998; **54**: 41–46.
4 Thornton PD, Simon S, Mathew TH. Towards safer drug prescribing, dispensing and administration in hospitals. *J Qual Clin Pract* 1999; **19**: 41–45.
5 Bates WD, Boyle DL, Van der Vliet MB, Schneider J, Leape L. Relationship between medication errors and adverse drug events. *J General Intern Med* 1995; **10**: 199–205.
6 Levens-Lipton H, Byrns PJ, Soumerai SB, Chrischilles EA. Pharmacists as agents of change for rational drug therapy. *Int J Technol Ass Health Care* 1995; **11**: 484–508.

7 Panton R, Fitzpatrick R. The involvement of pharmacists in professional and clinical audit in the UK. A review and assessment of their potential role. *J Eval Clin Pract* 1996; **2**: 193–198.

8 Ansari MZ, Collopy BT, Brosi JA. Errors in drug prescribing. *J Qual Clin Pract* 1995; **15**: 183–190.

9 Hawkey CJ, Hodgson S, Norman A, Daneshmend TK, Garner ST. Effect of reactive pharmacy intervention on quality of hospital prescribing. *Br Med J* 1990; **300**: 986–990.

10 Strom B, Gibson GA. A systematic integrated approach to improvement of drug prescribing in an acute care hospital: a potential model for applied hospital pharmacoepidemiology. *Clin Pharmacol Ther* 1993; **54**: 126–133.

11 Lesar TS, Briceland L, Delcoure K, Parmalee JC, Masta-Gornic V, Pohl H. Medication prescribing errors in a teaching hospital. *JAMA* 1990; **263**: 2329–2334.

12 Schumok GT, Guenette AJ, Keys V, Hutchinson RA. Prescribing errors for patients about to be discharged from a University hospital. *Am J Hosp Pharm* 1994; **51**: 2288–2290.

13 Dean BS, Allan EL, Barber ND, Barker KN. Comparison of medication errors in an American and a British hospital. *Am J Health Syst Pharm* 1995; **52**: 2543–2549.

14 Lesar TS, Briceland L, Stein DS. Factors related to errors in medication prescribing. *JAMA* 1997; **277** (4): 312–317.

15 Lesar TS, Lomaestro BM, Pohl H. Medication-prescribing errors in a teaching hospital. *Arch Intern Med* 1997; **157**: 1569–1576.

16 Altman DG. *Practical Statistics for Medical Research*, 1st Edition, London: Chapman & Hall, 1991.

17 Paton J, Wallace J. Medication errors. *Lancet* 1997; **349**: 959–960.

18 Lesar TS. Errors in the use of medication dosage equations. *Arch Pediatr Adolesc Med* 1998; **152**: 340–344.

19 Lindley CM, Tully MP, Paramsothy V, Tallis RC. Inappropriate medication is a major cause of adverse drug reactions in elderly patients. *Drugs Ageing* 1992; **21**: 294–300.

20 McMullin ST, Reichley RM, Kahn MG, Dunagan WC, Bailey TC. Automated system for identifying potential dosage problems at a large University hospital. *Am J Health Syst Pharm* 1997; **54**: 545–549.

21 Tully MP, Tallis R. Inappropriate prescribing and adverse drug reactions in patients admitted to an elderly care unit. *J Geriatr Drug Ther* 1991; **6**: 63–74.

22 Rowe C, Koren T, Koren G. Errors by paediatric residents in calculating drug doses. *Arch Dis Child* 1998; **79**: 56–58.

23 Raju TNK, Thornton JP, Kecskes S, Perry M, Feldman S. Medication errors in neonatal and paediatric intensive-care units. *Lancet* 1989; **i**: 374–376.

24 Koren G, Haslam RH. Pediatric medication errors. Predicting and preventing tenfold disasters. *J Clin Pharmacol* 1994; **34**: 1043–1045.

25 Feely J, Chan R, McManus J, O'Shea B. The influence of hospital-based prescribers on prescribing in general practice. *Pharmacoeconomics* 1999; **16**: 175–181.

26 Bijl D, Van Sonderen E, Haaijer-Ruskamp FM. Prescription changes and drug costs at the interface between primary and specialist care. *Eur J Clin Pharmacol* 1998; **54**: 333–336.

27 Fijn R, Brouwers JRBJ, De Jong-Van den Berg LTW. Cross-sectoral pharmacotherapeutic coherence in The Netherlands. *Int J Pharm Pract* 1999; **7**: 159–166.

28 Ho L, Brown GR, Millin B. Characterization of errors detected during central order review. *Can J Hosp Pharm* 1992; **45**: 193–197.

29 Cotter SM. Avoiding drug errors. Pharmacists and computerised prescribing can help. *Br Med J* 1995; **311**: 1367–1368.

30 Bates DW, Leape LL, Cullen DJ, *et al*. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA* 1998; **280**: 1311–1316.

31 Buurma H, de Smet PAGM, van Hoff OP, Egberts ACG. Nature, frequency, and determinants of prescription modification in Dutch community pharmacies. *Br J Clin Pharmacol* 2001; **52**: 85–92.