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The prevalence and nature of prescribing and monitoring errors in English general practice:

a retrospective case note review

Abstract

Background

Relatively little is known about prescribing errors in general practice, or the factors associated with error.

Aim

To determine the prevalence and nature of prescribing and monitoring errors in general practices in England.

Design and setting

Retrospective case-note review of unique medication items prescribed over a 12-month period to a 2% random sample of patients. Fifteen general practices across three primary care trusts in England.

Method

A total of 6048 unique prescription items prescribed over the previous 12 months for 1777 patients were examined. The data were analysed by mixed effects logistic regression. The main outcome measures were prevalence of prescribing and monitoring errors, and severity of errors, using validated definitions.

Results

Prescribing and/or monitoring errors were detected in 4.9% (296/6048) of all prescription items (95% confidence interval [CI] = 4.4% to 5.5%). The vast majority of errors were of mild to moderate severity, with 0.2% (11/6048) of items having a severe error.

After adjusting for covariates, patient-related factors associated with an increased risk of prescribing and/or monitoring errors were: age <15 years (odds ratio [OR] = 1.87, 95% CI = 1.19 to 2.94, $P=0.006$) or >64 years (OR = 1.68, 95% CI = 1.04 to 2.73, $P=0.035$), and higher numbers of unique medication items prescribed (OR = 1.16, 95% CI = 1.12 to 1.19, $P<0.001$).

Conclusion

Prescribing and monitoring errors are common in English general practice, although severe errors are unusual. Many factors increase the risk of error. Having identified the most common and important errors, and the factors associated with these, strategies to prevent future errors should be developed, based on the study findings.

Keywords

general practice; medication errors; prevalence; primary health care.

INTRODUCTION

The prescription of medication is the most common form of medical treatment in primary care and over 900 million items are dispensed in the community in England each year.¹ Prescribing is therefore an essential skill for GPs. For every prescribing decision, the potential for benefit needs to be balanced against the risk of harm. The prescriber must use clinical knowledge to apply bodies of evidence, rules, and guidance to a prescribing decision, while also taking into account the patient's view. The challenge of prescribing has increased, owing to the increased complexity of medical care, and the treatment of older and more severely ill patients.² Errors can occur in this process. In primary care, published error rates per prescription item vary from less than 1%,³ to over 40%,⁴ the latter being a Swedish study where failure to document the indication for a drug was considered an error. Such variation in error rates is likely to be significantly affected by the definition of error and the rigour with which error detection is undertaken. Nevertheless, prescribing

errors in primary care are a preventable source of harm, with a systematic review showing that they account for around 3.7% of hospital admissions.⁵

Relatively little is known about prescribing errors in general practice, or the factors associated with error. In one study, prescriptions were screened by community pharmacists for prescribing errors; prescribing errors were identified in 7.5% of prescribed items.⁶ A study in care homes showed that 39% of 256 residents had one or more prescribing errors, with 8.3% of prescription items (or intended prescription items) affected.⁷ According to the UK's National Patient Safety Agency, 26% of general practice incidents reported to the National Reporting and Learning System relate to medication,⁸ and 25% of adverse incidents that resulted in litigation claims in general practice were a result of medication errors, suggesting consequences not only for patient safety but also for practitioners.⁹

Given the paucity of research in this field, a large-scale study was conducted, with the aim of investigating the prevalence and

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How this fits in

Prescribing errors are known to be a problem in general practice, but estimates of prevalence vary widely and little is known about the frequency of different types of error or the factors associated with error. In this study, prescribing or monitoring errors were detected in one in 20 prescription items and the vast majority were of mild to moderate severity. A number of factors were associated with prescribing and/or monitoring errors; these included age, sex, number of unique prescriptions per patient, and prescriptions from specific therapeutic groups. Having identified the most common and important errors, and the factors associated with these, it will be possible to devise effective strategies for preventing errors in the future.

nature of prescribing and monitoring errors in general practice in England, along with the factors associated with errors.

METHOD

Setting and selection of general practices

Three English primary care trusts (PCTs) with differing characteristics (inner-city London, urban, and suburban/rural) were approached to act as sites for recruitment of general practices.

Between May and August 2010, all 97 general practices from these PCTs were invited to take part. Thirty replied and 20 expressed an interest in taking part. A total of fifteen were then purposefully selected to obtain a wide spread of different types of practice.

Sample size calculation

On the basis of previous studies, the best estimate for the prescribing error rate in primary care was around 8%.^{6,7} It was calculated that if a similar prevalence of prescribing errors were to be found in the present study, 3750 prescription items needed to be reviewed, in order to report this with a two-sided 95% confidence interval (CI) and accuracy of $\pm 1.6\%$. This allowed for the clustered design and assumed a total of 15 practices, an intra-class correlation coefficient of 0.01 (based on the authors' previous studies),¹⁰ and an average cluster size of 250 prescription items reviewed per practice.

The records of a 2% random sample of patients within each general practice were investigated to comfortably exceed the target of 3750 prescription items and thus increase the precision of the estimate of the error rate.

Definitions

The definition of a prescribing error used was one originally developed with hospital-based practitioners:

"A ... 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 ... increase in the risk of harm when compared to generally accepted practice."¹¹

This definition is accompanied by a list of examples of what should and should not be included as an error.

A monitoring error was defined, based on the consensus definition of Alldred *et al*, together with a list of medications that need blood-test monitoring and its frequency:

"A monitoring error occurs when a prescribed medicine is not monitored in the way which would be considered acceptable in routine general practice. It includes the absence of tests being carried out at the [required] frequency ..., with tolerance of $\pm 50\%$ If a patient refused to give consent for a test, then this would not constitute an error."¹²

For the purposes of this study, a list of medications requiring blood-test monitoring was used, along with recommended monitoring intervals (Box 1).

Identification and classification of prescribing and monitoring errors

Data were collected by four pharmacists trained by the research team to identify potential errors from GP records. Data were collected between August 2010 and April 2011. The pharmacists undertook a retrospective review of unique prescription items issued to patients in the 12 months prior to the date of data collection (for any prescription that was repeated during the study period, only the latest of these was examined). The pharmacists identified any potential prescribing or monitoring errors, having taken account of detailed information in patients' medical records relating to patient characteristics, comorbidities, other medications, allergies, and the need for monitoring.

The details of all potential errors were discussed by a panel (a GP, a clinical pharmacologist, and three pharmacists), to decide whether they fitted the error definition, taking into account practice in primary care, and, if so, how the error

Box 1. Medicines requiring blood test monitoring

The following medications were reviewed to determine whether blood-test monitoring had been done before or soon after the initiation of therapy (for medication that had recently been started), or as part of ongoing maintenance for patients on longer term therapy.

Monitoring before or soon after the initiation of therapy

Drug/drug group	Monitoring requirements
Angiotensin-converting enzyme inhibitor/ Angiotensin II receptor antagonists	Renal function and electrolytes before starting therapy, repeated 2 weeks after initiation Renal function and electrolytes before starting therapy, repeated 2 weeks after initiation
Digoxin	Renal function and electrolytes before starting therapy
Diuretics	Renal function and electrolytes before starting therapy
Glitazones	Liver function tests before starting therapy
Statins	Liver function tests before starting therapy

Monitoring of longer-term therapy

Drug/drug group	Monitoring requirements
Angiotensin-converting enzyme inhibitor/ Angiotensin II receptor antagonists	12-monthly renal function and electrolytes 12-monthly renal function and electrolytes 6-monthly thyroid function tests 6-monthly liver function tests
Amiodarone	3-monthly full blood count
Azathioprine	3-monthly thyroid function tests (6-monthly if patient been stabilised for over 1 year)
Carbimazole	Digoxin level if toxicity or lack of efficacy suspected. 12-monthly renal function and electrolytes 12-monthly liver function tests
Digoxin	12-monthly thyroid function tests
Diuretics	3-monthly lithium concentration
Glitazone	12-monthly thyroid function tests
Levothyroxine	3-monthly full blood count
Lithium	3-monthly liver function tests
Methotrexate	6-monthly renal function and electrolytes Full blood count 3-monthly in first year Liver function tests 3-monthly in first year Full blood count 6-monthly in second year Liver function tests 6-monthly in second year No further monitoring if stable
Sulfasalazine	Liver function tests within 3 months, and at 12 months, of starting treatment
Statin	Theophylline level if toxicity suspected
Theophylline	3-monthly liver function tests for first 6 months
Valproate	12-weekly International Normalized Ratio
Warfarin	

should be classified in terms of error type. In the vast majority of cases, the pharmacists who had collected the data provided sufficient information for the panel to make a judgement. Where this was not the case, they were asked to provide further details, and to return to the general practice if needed. The panel maintained a cumulative list of classification decisions to ensure consistency throughout the study.

It became apparent that there were some problems that did not fit within the error definitions, but nevertheless represented less than ideal practice. Therefore, another category of problem, 'suboptimal prescribing', was created. The pharmacists also identified prescriptions associated with legal issues, but that did not fall into the definition of error; these were given a separate category of 'legal problem'. Each potential error was therefore classified as

a prescribing error, a monitoring error, suboptimal prescribing, legal problem, or no problem.

Error severity

The severity of each error, identified using a reliable validated 0–10 scale (0 = no risk of harm; 10 = death),¹³ was assessed by two GPs, two pharmacists, and one clinical pharmacologist. According to this method, the mean score across all five judges was used as the severity score, where errors with scores of <3 were considered minor, those between 3 and 7 moderate, and scores >7 severe.

Data relating to the characteristics of participating general practices

The general practices provided descriptive data, including list size (number of patients); age–sex breakdown of the practice population; number, sex, and types of GPs (and other prescribers) in the practice; whether the practice was a GP training practice, or a dispensing practice; and the clinical computer system used in the practice. Publicly available sources of data (Table 1) were used to obtain deprivation scores and Quality and Outcomes Framework points for the practices.

Data analysis

Data were entered onto a Microsoft® Access® 2007 database, and every item was checked by another member of the research team. Any data-entry errors were corrected and an audit trail was kept.

Categorical variables were described using frequencies and percentages, and means and standard deviations (SDs) or medians and interquartile ranges (IQRs) were used to summarise continuous variables, depending on their distribution.

The prevalence of prescribing and monitoring errors was estimated and 95% CIs reported. Multivariable analyses, modelling the relationships between the risk of error and selected predictor variables and a priori confounders, were performed at the patient level and at the prescription level respectively. The primary outcome measure was binary, indicating the presence of one or more prescribing or monitoring errors, and modelled using logistic regression. To estimate the relationship between prescribing and monitoring errors and relevant covariates, six logistic regression models were built as follows: (1) a univariate model using patient and general practice characteristics; (2) a multivariable model with all patient and general practice characteristics; (3) a

Table 1. Comparison of characteristics of general practices involved in the study with National figures for England

Characteristic	Mean (SD) across GP practices studied	Mean national figure ^a
Practice list size	5916 (3014)	6610 ^a
Number of GPs	5 (2.3)	4.73 ^b
Deprivation using IMD 2007 score	30.4 (18.2)	21.7 ^c
QOF medicines management points per practice, %	99.2% (2.0)	97.2% ^d
QOF total points per practice, %	92.5% (6.8)	93.7% ^d

IMD = Index of Multiple Deprivation. QOF = Quality and Outcomes Framework. SD = standard deviation. ^aFigures for England for 2010, obtained from the Health and Social Care Information Centre (<http://www.hscic.gov.uk/searchcatalogue?productid=10382&topics=2%ffPrimary+care+services%2fGeneral+practice%2fGeneral+Practice+workforce&sort=Most+recent&size=10&page=1#top>) data available in Microsoft Excel Workbook with file name 'NHS Staff – 2002–2012, General Practice Bulletin Tables'. ^bFigures for England for 2010 calculated from data obtained from the Health and Social Care Information Centre: total GPs in England: 39 409; total general practices: 8324 (<http://www.hscic.gov.uk/searchcatalogue?productid=10382&topics=2%ffPrimary+care+services%2fGeneral+practice%2fGeneral+Practice+workforce&sort=Most+recent&size=10&page=1#top>) data available in Microsoft Excel Workbook with file name 'NHS Staff – 2002–2012, General Practice Bulletin Tables'. ^cMean IMD score for English lower layer super output areas (available from <http://webarchive.nationalarchives.gov.uk/20100410180038/http://communities.gov.uk/communities/neighbourhoodrenewal/deprivation/deprivation07/>). ^d2010 Quality and Outcomes Framework figures for England (available from: <http://www.ic.nhs.uk/qof/>).

univariate model using prescription and prescriber characteristics; (4) a univariate model using prescription and prescriber characteristics, adjusting for patient

clustering; (5) a multivariable model with all prescription and prescriber characteristics; and (6) a multivariable model with all prescription and prescriber characteristics, adjusting for patient clustering. To take into account potential clustering, in models 4 and 6, patients were treated as random effects in a multilevel model to adjust for correlation. The significance of the variables in the models was assessed using the Wald χ^2 test and by determination of odds ratios (ORs) with associated 95% CIs. Statistical significance for all analyses was set at <0.05 (two-sided). All the statistical analyses were performed using STATA (version 11.2), and the xtmelogit command used to take into account possible clustering (patient).

RESULTS

General practices characteristics

The mean list size of the 15 general practices was 5916 (SD = 3014, range = 1600 to 12 000); 10 (67%) were involved in GP training, two (13%) were dispensing, and 12 (80%) were in an urban area. The practices used a range of different clinical computer systems.

Compared with figures for England, the study practices were reasonably representative in terms of list size and overall scores in the Quality and Outcomes Framework (Table 1), but appeared more deprived.

Medical records reviewed and patient characteristics

The study involved examination of the records of 1777 patients. All practices had computerised records and this was the main source of information; paper-based records (such as hospital correspondence) were used if these provided additional information. Data were available for all patients. These patients had a mean age of 39.5 years (SD = 22.6 years), and 49.7% (884/1777) were female. The age distribution of patients was similar to that of the English population for 2010,¹⁴ with 16.7% (297/1777) aged 0–14 years and 15.9% (283/1777) aged ≥65 years. Of the 1777 patients, 67.5% (1200/1777) had at least one prescription during the 12-month retrospective review of their records.

The pharmacists reviewed 6048 unique prescription items. Of these, 48.4% (2929/6048) were acute prescriptions, 51.6% (3119/6048) were repeat prescriptions, and 12.7% (770/6048) were items considered to require blood-test monitoring. A clear majority of the 6048 prescriptions (80.3% [4859/6048]) were issued by GP partners, 12.9% (779/6048) by salaried GPs, 3.1%

Table 2. Distribution of different types of prescribing errors

Types of prescribing error	Frequency	All errors, %
Incomplete information on prescription	74	30.0
Dose/strength error	44	17.8
Timing error	26	10.5
Frequency error	20	8.1
Omission of concomitant treatment	19	7.7
Unnecessary drug	12	4.9
Contraindication error	12	4.9
Incorrect drug	10	4.0
Duplication	9	3.6
Interaction error	9	3.6
Allergy error	3	1.2
Inadequate documentation in medical records	3	1.2
Quantity error	3	1.2
Formulation error	2	0.8
Generic/brand name error	1	0.4
Total	247	100.0
Type of monitoring error		
Monitoring not requested	38	69.1
Requested but not done	12	21.8
Results not available	5	9.1
Total	55	100.0

Box 2. Examples of errors judged to be of different grades of severity

Minor errors

- 1-year old girl prescribed amoxicillin 125 mg/5 ml suspension twice during the same consultation. One was for 2.5 ml three times daily for 1 week, and the other for 5 ml three times daily for 1 week.
- Topical betamethasone 0.1% prescribed in an adult patient. No directions given relating to the frequency of application.
- Betamethasone cream 0.1% prescribed 'to be applied sparingly for 1 week' for a 5-year-old child. No frequency of use specified.
- 29-year-old patient prescribed co-amoxiclav tablets 21 × 500 mg/125 mg for sinusitis. Dose and frequency not specified on prescription.

Moderate errors

- 64-year old patient prescribed ibuprofen 400 mg, one tablet to be taken three times daily, after a road accident. No concomitant medication was prescribed for gastric protection. Patient also on aspirin for peripheral vascular disease.
- Indometacin 50 mg prescribed with dosage instructions 'as directed', with no instructions on frequency or maximum daily intake. Patient diagnosed with alcoholic cirrhosis of the liver.
- Patient prescribed levothyroxine 25 µg, one tablet to be taken every day. Thyroid function tests were requested but not done.

Severe errors

- 62-year-old patient with documented allergy to penicillin; prescribed a course of oral flucloxacillin.
- Aciclovir 200 mg prescribed, one tablet to be taken five times a day for widespread cold sores, to a patient with a documented severe allergic reaction to aciclovir.
- Older patients on warfarin. Last documented international normalised ratios were more than 2 years previously ($n = 7$ errors).
- 93-year-old patient prescribed warfarin. Last documented international normalised ratio was more than 1 year previously. Patient did not attend three consecutive anticoagulant appointments, but warfarin prescription continued.

(185/6048) by locum GPs, 2.2% (133/6048) by GPs in training, and 1.0% (60/6048) by non-medical prescribers; for 0.5% (33/6048) the type of prescriber was not identified.

Prevalence of errors and other problems

From the 6048 prescription items reviewed, there was a prevalence of:

- 4.1% [247/6048; 95% CI = 3.6% to 4.6%] prescribing errors;
- 0.9% [55/6048; 95% CI = 0.7% to 1.1%] monitoring errors;
- 7.1% [427/6048; 95% CI = 6.4% to 7.7%] suboptimal prescribing;
- 0.1% [8/6048; 95% CI = 0.06% to 0.3%] legal problems.

Restricting analysis to the 770 prescription items that required blood-test monitoring showed a prevalence of monitoring errors of 6.9% [53/770; 95% CI = 5.2% to 8.9%].

The prevalence of prescription items with at least one prescribing and/or monitoring error was 4.9% [296/6048; 95% CI = 4.4% to 5.5%], with a small number of prescriptions containing more than one error. There were 247 prescribing errors and the most common types were incomplete information on the prescription; dose/strength error; and incorrect timing of doses (Table 2). There were 55 monitoring errors and the most common type was failure to request monitoring.

Table 3. Patient-level model of risks associated with prescribing or monitoring errors ($n = 1777$)

Factor	Univariate models (model 1)			Multivariable models (model 2)		
	Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Sex						
Male ^a	1.00			1.00		
Female	0.76	0.56 to 1.02	0.064	0.66	0.48 to 0.92	0.013
Number of drugs	1.17	1.13 to 1.20	<0.001	1.16	1.12 to 1.19	<0.001
Age category, years						
15–64 ^a	1.00			1.00		
0–14	1.53	0.99 to 2.35	0.053	1.87	1.19 to 2.94	0.006
65–74	2.69	1.73 to 4.20	<0.001	1.68	1.04 to 2.73	0.035
≥75	4.26	2.81 to 6.47	<0.001	1.94	1.19 to 3.19	0.008
Dispensing practice						
Non dispensing ^a	1.00			1.00		
Dispensing practice	1.05	0.73 to 1.51	0.781	0.70	0.26 to 1.88	0.476
Training practice						
Training ^a	1.00		1.00			
Not a training practice	1.33	0.98 to 1.81	0.065	1.39	0.97 to 2.01	0.075
Practice size						
5000–10 000 ^a	1.00			1.00		
<5000 patients	0.83	0.58 to 1.17	0.281	0.88	0.58 to 1.34	0.553
>10 000 patients	0.74	0.49 to 1.11	0.147	0.56	0.31 to 0.99	0.047
Location						
Urban ^a	1.00			1.00		
Rural practice	1.03	0.74 to 1.44	0.849	1.06	0.43 to 2.58	0.905

^aReference group.

For the 12-month data-collection period, of the patients who received at least one medication, 18.7% [224/1200; 95% CI = 16.5% to 21.0%] had at least one prescribing and/or monitoring error. For patients aged ≥ 75 years who had received at least one medication, the prevalence was 41.9% [54/129; 95% CI = 33.2% to 50.9%]. For patients who had received five or more medications over the data-collection period, the prevalence of error was 32.3% [152/471; 95% CI = 28.1% to 36.7%], and for patients who had received 10 or more drugs, the prevalence was 48.8% [84/172; 95% CI = 41.2% to 56.6%].

Error severity

Of the 302 prescribing and monitoring

errors, 42.4% [128/302] errors had scores of <3 , and were thus deemed to be minor; 54.0% [163/302] had scores of 3–7 and were thus moderate; 3.6% [11/302] had scores >7 and were thus severe. The median severity score was 3.3 (IQR = 2.2 to 4.4, minimum 0.7, maximum 8.6). The 55 monitoring errors had a median score of 3.8; the 247 prescribing errors had a lower median score of 3.0. Examples of errors of different severity are shown in Box 2. On the basis of the data collected in this study, no patient was hospitalised or died as a result of the errors detected.

Factors associated with prescribing or monitoring errors

Several significant associations were found

Table 4. Prescription-level univariate models of risks associated with prescribing or monitoring errors: unadjusted and adjusted for patient clustering

Factor	Univariate unadjusted model ^a (model 3)			Univariate adjusted model ^b (model 4)		
	Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Medication on monitoring list	3.32	2.56 to 4.30	<0.001	3.57	2.68 to 4.75	<0.001
Repeat prescription ^c	1.40	1.10 to 1.78	0.006	1.39	1.08 to 1.79	0.011
Formulation^d						
Eye/ear drops	2.01	1.21 to 3.33	0.007	2.08	1.20 to 3.59	0.009
Inhalers	0.41	0.21 to 0.81	0.010	0.40	0.20 to 0.79	0.009
Injections	0.51	0.24 to 1.10	0.447	0.51	0.23 to 1.11	0.091
Liquid oral	0.82	0.49 to 1.38	0.087	0.80	0.46 to 1.38	0.414
Rectal	0.80	0.11 to 5.95	0.827	0.97	0.12 to 7.72	0.973
Topical	0.98	0.70 to 1.37	0.905	1.00	0.70 to 1.43	0.992
Prescriber type^e						
Salaried GP	0.62	0.41 to 0.95	0.026	0.64	0.41 to 1.00	0.051
Locum GP	1.07	0.56 to 2.05	0.835	1.12	0.55 to 2.27	0.760
Training GP	1.36	0.68 to 2.71	0.380	1.34	0.63 to 2.85	0.441
Non-medical prescriber	0.99	0.31 to 3.17	0.982	0.87	0.25 to 3.06	0.832
Other/unknown	1.94	0.59 to 6.41	0.277	1.78	0.50 to 6.43	0.358
British National Formulary chapter^f						
Cardiovascular system	5.53	2.66 to 11.49	<0.001			
Respiratory system	1.58	0.65 to 3.84	0.315			
CNS	2.06	0.94 to 4.49	0.07			
Infections	2.37	1.07 to 5.24	0.034			
Endocrine	2.87	1.23 to 6.73	0.015			
Obstetrics, gynaecology, urinary tract disorders	1.09	0.33 to 3.66	0.887			
Malignant disease and immunosuppression	14.00	3.84 to 51.07	<0.001			
Nutrition and blood	1.17	0.35 to 3.92	0.803			
Musculoskeletal	6.38	2.87 to 14.21	<0.001			
Eye	6.61	2.74 to 15.92	<0.001			
Ear nose and oropharynx	3.50	1.29 to 9.50	0.014			
Skin	3.52	1.63 to 7.59	0.001			
Immunology and vaccines	2.18	0.74 to 6.37	0.155			
Computer system^g						
EMIS PCS	1.15	0.87 to 1.53	0.322	1.17	0.83 to 1.64	0.371
Isoft Premiere	0.67	0.45 to 0.98	0.040	0.64	0.40 to 1.00	0.051
TPP	1.13	0.79 to 1.63	0.507	1.06	0.68 to 1.65	0.812

CNS = central nervous system. ^aModel unadjusted for clustering by patient. ^bModel adjusted for clustering by patient. ^cAcute prescriptions. ^dSolid oral medication (pessaries category omitted). ^eGP partner. ^fGastrointestinal (anaesthesia chapter omitted). ^gEMIS LV.

Table 5. Prescription-level multivariable models of risks associated with prescribing or monitoring errors: unadjusted and adjusted for patient clustering

Factor	Multivariable unadjusted model (model 5) ^a			Multivariable adjusted model (model 6) ^b		
	Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Medication on monitoring list	3.18	2.05 to 4.94	<0.001	3.63	2.65 to 4.98	<0.001
Repeat prescription ^c	1.25	0.91 to 1.72	0.168	0.98	0.73 to 1.31	0.903
Formulation^d						
Eye/ear drops	1.43	0.39 to 5.23	0.586			
Inhalers	0.51	0.21 to 1.27	0.149			
Injections	0.41	0.06 to 3.07	0.387			
Liquid oral	1.08	0.60 to 1.95	0.794			
Rectal	1.93	0.24 to 15.42	0.535			
Topical	0.66	0.31 to 1.42	0.287			
Prescriber type^e						
Salaried GP	0.71	0.46 to 1.11	0.13	0.76	0.47 to 1.22	0.258
Locum GP	1.16	0.60 to 2.28	0.655	1.23	0.60 to 2.54	0.576
Training GP	1.42	0.67 to 3.01	0.353	1.66	0.74 to 3.72	0.218
Non-medical prescriber	1.55	0.47 to 5.13	0.469	1.09	0.30 to 3.91	0.898
Other/unknown	1.78	0.52 to 6.14	0.358	1.97	0.54 to 7.23	0.305
British National Formulary chapter^f						
Cardiovascular system	2.37	1.03 to 5.45	0.042			
Respiratory system	2.26	0.83 to 6.17	0.11			
CNS	2.09	0.95 to 4.63	0.068			
Infections	2.67	1.17 to 6.11	0.02			
Endocrine	1.91	0.78 to 4.72	0.159			
Obstetrics, gynaecology, urinary tract disorders	1.41	0.41 to 4.80	0.584			
Malignant disease and immunosuppression	6.77	1.71 to 26.84	0.006			
Nutrition and blood	1.22	0.36 to 4.15	0.752			
Musculoskeletal	6.97	3.06 to 15.88	<0.001			
Eye	4.92	1.12 to 21.62	0.035			
Ear nose and oropharynx	4.60	1.29 to 16.42	0.019			
Skin	5.78	2.04 to 16.36	0.001			
Immunology and vaccines	5.91	0.60 to 58.00	0.127			
Computer system^g						
EMIS PCS	1.06	0.79 to 1.42	0.706	1.13	0.80 to 1.60	0.501
Isoft Premiere	0.68	0.46 to 1.01	0.055	0.64	0.40 to 1.01	0.058
TPP	1.05	0.71 to 1.56	0.803	0.94	0.58 to 1.52	0.81

CNS = central nervous system. ^aModel unadjusted for clustering by patient. ^bModel adjusted for clustering by patient but formulation and chapter not included in the model due to non-convergence of model. ^cAcute prescriptions. ^dSolid oral medication (pessaries category omitted). ^eGP partner. ^fGastrointestinal (anaesthesia chapter omitted). ^gEMIS LV.

in the patient-level multivariable analysis (Table 3). For each additional unique medication item that the patient had received over the course of the 12-month data-collection period, there was a significant 16% increased risk of error (OR = 1.16, 95% CI = 1.12% to 1.19%, $P < 0.001$), and women were less likely than men to have a prescribing or monitoring error (OR = 0.66, 95% CI = 0.48 to 0.92, $P = 0.013$). Compared to those aged 15–64 years, patients who were <15 years had an 87% excess risk of error (OR = 1.87, 95% CI = 1.19 to 2.94, $P = 0.006$); those aged 65–74 years had a 68% excess risk (OR = 1.68, 95% CI = 1.04 to 2.73, $P = 0.035$), and those ≥75 years had a 94% excess risk (OR = 1.94, 95%

CI = 1.19 to 3.19, $P = 0.008$). There was a significant 44% risk reduction in errors in practices with more than 10 000 patients (OR = 0.56, 95% CI = 0.31 to 0.99, $P = 0.047$). Furthermore, non-training practices had borderline significant 39% excess risk of errors (OR = 1.39, 95% CI = 0.97 to 2.01, $P = 0.075$) compared to training practices.

The findings from the prescription-level model are shown in Table 4 (univariate modelling) and Table 5 (multivariable modelling). Two multivariable models are shown in Table 5 and these relate to models 5 and 6 described in the methods. Model 5 included all relevant variables, but did not adjust for clustering by patient. Model 6 did adjust for clustering by patient, but it was not

possible to include 'formulation' and 'British National Formulary chapter', owing to model non-convergence. Both models showed that prescribing a drug on the 'monitoring list' (see Box 1 for examples) was associated with a more than threefold increased risk of error (for model 6, OR = 3.63, 95% CI = 2.65 to 4.98, $P < 0.001$). Neither model showed a significant association between the type of prescriber or type of computer system and prevalence of error. Model 5 showed that prescriptions from the following *British National Formulary* chapters were significantly associated with excess risk of prescribing or monitoring errors compared to the gastrointestinal reference category: cardiovascular system (OR = 2.37, 95% CI = 1.03 to 5.45, $P = 0.042$), infections (OR = 2.67, 95% CI = 1.17 to 6.11, $P = 0.02$), malignant disease and immunosuppression (OR = 6.77, 95% CI = 1.71 to 26.84, $P = 0.006$), musculoskeletal (OR = 6.97, 95% CI = 3.06 to 15.88, $P < 0.001$), eye (OR = 4.92, 95% CI = 1.12 to 21.62), ear nose and oropharynx (OR = 4.60, 95% CI = 1.29 to 16.42, $P = 0.019$), and skin (OR = 5.78, 95% CI = 2.04 to 16.36, $P = 0.001$).

DISCUSSION

Summary

The prevalence of prescriptions with prescribing or monitoring errors found in the study was 4.9%. Around one in six of the population studied were exposed to a prescribing or monitoring error if they had been prescribed any medication during the 12-month data-collection period. Given that the study used a sample of practices and patients that was reasonably representative of England, it is believed that these figures give an estimate of the likely prevalence of prescribing and monitoring errors across the country. The vast majority of the errors were judged to be of minor or moderate severity, with one in 550 prescriptions associated with a severe error.

Strengths and limitations

The 15 general practices included in the study were reasonably representative of English general practices in terms of list size, number of GPs per practice, age profile, and points achieved in the Quality and Outcomes Framework, although they were more deprived. The sampling strategy enabled GP training practices and dispensing practices to be included. Compared with overall figures for England, the practices were more deprived.

To avoid any problems with sampling bias at the practice level, a random sample of patients was obtained from each practice.

However, it is possible that the recruited practices had relatively high levels of interest in prescribing compared with other practices, and a greater openness to external scrutiny of potential prescribing errors, which could have caused the study to underestimate the true rate of prescribing errors. The pharmacists who collected data for the study all had clinical experience and were provided with training in identifying errors. Nevertheless, it is possible that they varied in their ability to detect potential prescribing and monitoring errors. A validated approach to the definition of error was used in the study, and a multidisciplinary panel was used to decide whether an error was present or not. A consistent approach was also used throughout the study to the application of the error definitions used. Nevertheless, it is possible that a different panel would have come to different judgements, and this highlights one of the challenges of consistent application of error definitions across studies. The present study focused on errors associated with prescribing and blood test monitoring. With more resources, it would have been helpful to have investigated errors associated with other aspects of medicines management in primary care, as done recently in English care homes.⁶

The multivariable analysis undertaken allowed associations between the prevalence of prescribing and monitoring errors and a range of factors to be explored, while taking account of potential confounders. Statistical significance for all analyses was set at < 0.05 (two-sided) and some may regard this as relatively weak. Nevertheless, many of the findings were highly statistically significant.

Comparison with existing literature

This study was larger than previous UK studies, and used robust methods and definitions. The error rates are in line with those reported previously,³⁻⁶ but the large and representative sample makes the estimates more precise. The most recent of previous studies found a prevalence of prescribing error of 8.3% and monitoring error of 14.7%,⁷ albeit it in residential and nursing home patients.⁷ In contrast, the prevalence of prescribing errors in UK hospitals was 8.9%,¹⁵ and in a US hospital was 6.2%.¹⁶ Internationally, prescribing errors affect a median of 7% (IQR = 2-14) of medication orders in hospitals.¹⁷

The prevalence of prescribing or monitoring errors was particularly high in certain groups of patients: older people,

children, men, and those on multiple medications. The high prevalence in older people has been noted elsewhere,⁶ and is of particular concern because of greater susceptibility of older people to experiencing medication-related harm. The high prevalence in children highlights the need to ensure that correct doses are prescribed with clear dosage instructions, but despite concerns from another study, off-label and unlicensed prescribing was not found to be an important cause of error.¹⁸ The finding that patients taking multiple medications have increased risk of error (an association that went beyond the additive effect of each medicine) is of concern, especially as those taking 10 or more medicines had an almost 50% risk of an error during a 12-month period. These findings support those of other studies,¹⁹ and highlight the need to find more effective ways of managing polypharmacy.²⁰ The lower risk of error in women is a surprising finding, and is in contrast to findings suggesting that women are at greater risk of adverse drug events.²¹ It is possible, however, that GPs are more cautious when prescribing for women, hence the lower risk of error.

Drugs associated with a higher risk of error included those requiring a monitoring test, musculoskeletal drugs (most commonly non-steroidal anti-inflammatory drugs), and those used for malignant disease and immunosuppression (although the sample was small in this last group). This highlights the need for GPs to pay particular attention to correct prescribing and monitoring of medications associated with the highest risk of error (and associated adverse events). Some of the most serious errors related to the prescription of warfarin without access to blood-test monitoring (Box 2). Given the dangers associated with this drug, it is essential that prescribers have access to the latest international normalised ratio before prescribing, and adhere to local and national policies.²² In addition, this study identified two cases in which drugs were prescribed for patients with a computer-recorded allergy to the drug. Given the design of GP computer systems, it is almost certain that these prescribers would have overridden a hazard alert. Therefore, there is a need to make it more difficult for prescribers to override alerts for the most serious hazards.²³

In addition to the points made above, there are several other approaches by which prescribing and monitoring errors could be reduced in general practices, based on the findings of this study. Given that the most common type of error detected in the

study was 'incomplete dosage instructions', it is important for GPs to take the time needed to provide clear and complete instructions, particularly for high-risk medicines. To help with this, the latest GP computer systems are able to provide 'order sentences' (dosage instructions) that are appropriate for each medication prescribed. Greater use of this functionality by GPs could substantially reduce error rates. Given that monitoring errors are another common category of error, it is important for general practices to ensure that they have robust systems in place to make sure that essential blood-test monitoring is done. GP computer systems can help with identifying patients who need monitoring, and this can also be done at prescription reviews. These reviews can also act as an opportunity to identify and correct errors, but the present study showed that repeat prescriptions were no less likely to contain an error than acute prescriptions. This suggests that prescription reviews may not be as effective as they could be, especially in patients taking multiple medications, and in higher-risk complex patients. It may be helpful to consider different models for conducting these reviews. For example, involving pharmacists and geriatricians in the review of older patients on multiple medications may help reduce unnecessary polypharmacy,²⁰ and also reduce errors.

Pharmacists can also help GPs to reduce prescribing errors by identifying patients at risk (based on searches of the GP computer system), and facilitating appropriate management of any problems identified.²⁴ This approach, would be suitable for tackling some of the errors observed in this study, particularly monitoring errors. Overall, there is considerable scope for GP computer systems to help reduce many of the prescribing errors identified in this study. In addition to points made already, the most advanced systems can help provide advice on correct dosage, based upon a patient's age, weight, and/or renal function. They can also provide alerts for contraindicated prescribing. A key challenge, however, is to avoid over-alerting prescribers, and to design systems to minimise the risk of accidentally overriding alerts for potentially fatal errors.

It should be noted that the study reported in this paper was part of a larger investigation funded by the General Medical Council (GMC) in the UK, and further details are available from the GMC website.²⁵

Implications for future research

Further research is now needed to develop

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Ethical approval

Approval was obtained from Nottingham Research Ethics Committee 1 (Reference 10/H0403/29; 27 April 2010). NHS Research and Development approval was obtained from participating PCTs. The ethics committee agreed that patients did not have to give informed consent. No personal identifiable data were recorded.

Provenance

Freely submitted; externally peer reviewed.

Competing interests

The authors have declared no competing interests.

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and test interventions to reduce the prevalence of prescribing and monitoring errors in general practices. It is already known that computerised clinical decision support can help reduce prescribing errors in hospitals,²⁶ but there is a need for more studies in primary care, particularly to evaluate the more sophisticated systems in current use and to determine whether there are safety benefits to reducing the hazard-alert burden on prescribers. Further research is also needed into whether the prevalence of prescribing and monitoring errors in general practice can be reduced by education, training, audit, and practical support, as demonstrated previously.²⁴ It is also important to evaluate the effectiveness of systems-based approaches to reducing prescribing and monitoring errors whereby processes used in general practices such as repeat prescribing, medication review, and monitoring are optimised. Finally, it would be helpful to do further research to determine the extent to which the

prevalence of prescribing and monitoring errors can be reduced by more extensive involvement of clinical pharmacists in promoting high-quality, safe prescribing in general practice. For example, a model could be developed in which pharmacists work with GPs to address the most important factors associated with error.

Prescribing or monitoring errors occurred in one in 20 prescription items, and most of these were judged to be of mild to moderate severity; one in 550 prescription items contained a severe error. The risks of error were higher in children, older people, male patients, and those on multiple medications. Several groups of drugs were associated with higher risks of error, including those requiring blood-test monitoring. Having identified the most common and important errors, and the factors associated with these, strategies to prevent future errors should be developed, based on the study findings.

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