

FINAL report

An in depth investigation into causes of prescribing errors by foundation trainees in relation to their medical education.

EQUIP study.

Tim Dornan (Principal Investigator), Darren Ashcroft, Heather Heathfield, Penny Lewis, Jon Miles, David Taylor, Mary Tully, Val Wass

Correspondence

Professor Tim Dornan

Hope Hospital (University of Manchester Medical School Teaching Hospital)

Stott Lane, Salford, Greater Manchester M6 8HD

Tel: +44 (0)161 206 1384

Fax: +44 (0)161 206 5989

Email: tim.dornan@manchester.ac.uk

Executive Summary

Aim

This programme of research aimed to explore the causes of prescribing errors made by first year foundation trainee (FY1) doctors, concentrating on the interplay between their educational backgrounds and factors in their practice environments. It aimed also to arrive at evidence-based recommendations to improve patient safety and define a future research agenda.

Methods

Its methods included 1) three systematic literature reviews (two of which have been published at the time of this report), 2) a large empirical evaluation of the prevalence and nature of prescribing errors made by FY1 trainees from a range of educational backgrounds, 3) an in-depth qualitative exploration of the causes of such errors using a critical incident approach, and 4) telephone interviews of leaders of the undergraduate programmes in which the FY1 trainees who participated in 3) had been educated. The results of those individual studies were triangulated against one another and synthesised into an interpretation from which recommendations could be made.

Results

Prevalence

11,077 errors were detected in 124,260 medication orders checked on seven 'census days' in 19 acute hospital trusts in North-west England, a mean error rate of 8.9 errors per 100 medication orders. There were 4190 errors in 50,016 medication orders written by FY1 doctors, an error rate of 8.4%. All grades of doctor (including consultants) made prescribing errors and the highest error rate (of 10.3%) was in foundation year 2 doctors. Errors were most often made at the time of patients' admission to hospital. The classes of drug most commonly involved were analgesics, antibacterials, bronchodilators, and antianginals. Almost all errors were intercepted by pharmacists before they could affect patients.

The systematic review found a slightly lower error rate (median 7%, interquartile range 2-14%) of medication orders, 52 (8-227) errors per 100

admissions, and 24 (6-212) errors per 1000 patient days. As in our prevalence study, most errors were intercepted and reported before they caused harm although two studies collected data about errors that had caused adverse drugs events. Errors were commonest with antimicrobials and commoner in adults than children. Incorrect dosage, as in our study, was the commonest error. Disparities in data collection methods and definitions made data synthesis very difficult.

Causes

The systematic review of causes, like the prevalence review, showed a level of inconsistency between studies that made quantitative synthesis impractical; its findings were so consonant with our empirical study of causes that they are not discussed separately here.

A 'safety culture' was conspicuous by its absence from respondents' discourses of their prescribing errors, the reported culture of their working environments, and the reported actions of other doctors. Doctors relied heavily on pharmacists and nurses to identify and correct errors. FY1 trainees were often inadequately supported when prescribing, particularly on-call and during ward rounds. Errors resulted from complex mixtures of antecedent and contextual factors, which could best be described as complex adaptive systems rather than simple, linear relationship between causes and effects. From that perspective, routine violations of prescribing rules, for example, were understandable adaptations to busy and stressful working conditions rather than aberrations. Miscommunication on the part of third parties, including patients, led to FY1 trainees' errors.

When a deficiency of knowledge or skill caused an error, it was not the sole cause of that error, and the knowledge that was lacking was a complex, contextual type of knowledge more than the underpinning theory or type of declarative knowledge commonly taught in undergraduate programmes. Respondents did, however, report deficiencies in their education in prescribing skills and error prevention. More could have been done during undergraduate education to link theory with practice, and develop medical

students' expertise in the complex context of clinical practice. When lack of knowledge led to errors, those errors might have been prevented by better support in the working environment. 'Just-in-time' education in practical prescribing during the FY1 year, when offered, was valued by trainees and more would have been appreciated.

Recommendations

This research has identified five main targets for interventions to improve patient safety by minimising prescribing errors. Because of the dearth of prior evidence about the causes of prescribing errors and efficacy of interventions, these recommendations are made with the proviso that exploratory research will be required to demonstrate their efficacy. The targets are:

- Clinical working environments
- Undergraduate medical education programmes
- Foundation Year 1 education
- Other parts of the medical education continuum
- Interprofessional education

Future research should evaluate complex interventions, including novel instructional designs delivered in undergraduate and early postgraduate education and quality improvement initiatives delivered within communities of practice. Generic competences – such as seeking information, help, and feedback on performance – should be developed as well as competences specifically related to prescribing.

Acknowledgements

We thank Lindsay Harper, Katy Mellor, Steve Williams, Keith Harkins, Steve McGlynn and Ray George for their expert and good-natured contributions to the error validation panels. The pharmacists who collected data on the 19 study sites are too numerous to mention individually, but we extend our thanks to them all. We thank Kathryn Bell and Jodie Blackadder-Coward for helping with the first systematic review and giving us a medical student perspective on the research. We thank the doctors who participated in the research interviews for being willing to give their time and for frankly disclosing their sometimes sensitive experiences. We owe very special thanks to our 'critical friends', Graham Buckley, Gary Cook, Dianne Parker, Lesley Pugsley, and Mike Scott, who formed an expert advisory group providing English, Welsh, Scottish, and Northern Irish perspectives on the research, and helped us at every stage along the way.

Glossary

A & E	Accident and emergency
ADHD	Attention deficit hyperactivity disorder
Active failure	Unsafe act committed by person who is in direct contact with the patient or system; includes slip, lapse, mistake, and violation.
BNF	British National Formulary
CD	Controlled drug
CIT	Critical incident technique
CL	Curriculum lead
DVT	Deep vein thrombosis
E-prescribing	Electronic prescribing
Error-producing condition	Condition which may predispose to an active failure
Foundation programme	Two-year generic training programme which forms the bridge between medical school and specialist/general practice training.
FY1	Foundation Year One doctor The first year of the Foundation Programme. Learning objectives for this year are set by the General Medical Council (GMC). In order to attain full registration with the GMC, doctors must achieve specific competences by the end of this year.
FY2	Foundation Year two doctor The second year of the Foundation Programme. Its main focus is on training in the assessment and management of the acutely ill patient. Training also encompasses generic professional skills applicable to all areas of medicine – team-work, time management, communication and IT skills.
FTSTA	Fixed term specialty training appointment of up to one years duration in the early years of Specialty Training
GMC	General Medical Council
GORD	Gastro-oesophageal reflux disease
GP	General practitioner
GTN	Glyceryl trinitrate

Just-in-time training	A method of providing training when it is needed. Its advantage is that it eliminates the need for refresher training due to subject knowledge loss when the learner cannot use material immediately after initial training.
KBM	Knowledge-based mistake Mistakes that occur at the knowledge based performance level. Occur when faced with novel task and have to consciously construct plan of action. Occur when an inappropriate plan or incorrect plan is correctly executed.
Latent failure	'Resident pathogens' in the system arising from decisions made by designers, builders and top level management
MAU	Medical admissions unit
Memory Lapse	An error involving failures of memory
NCCG	Non consultant career grade staff, including staff grade doctors and senior associate specialists
PPI	Proton-pump inhibitor
PRHO	Pre-Registration House Officer; now outdated termed sometimes used to mean FY1 trainee.
Pt	Patient
QDS	Quater die sumendum (to be taken four times daily)
RBM	Rule-based mistake Mistakes that occur at the rule-based performance level when drawing on a set of stored mental if-then rules. Occur when an inappropriate plan or incorrect plan is correctly executed.
Skill-based slip	An active failure resulting from the incorrect execution of a task
SpR	Specialist registrar A doctor receiving advanced training in a specialist field
SHO	Senior House Officer; now outdated term meaning doctor registered with the GMC undergoing basic specialist training. Equivalent to FY2 trainee
TDS	Ter die sumendum (to be taken three times daily)
TTA	'To take away' medication that is supplied on discharge; sometimes also abbreviated to TTO ('to take out')

Contents

1.0 Introduction.....	11
1.1 The research team.....	12
1.2 Project roles and management.....	12
1.3 Project advisory group.....	13
1.4 Ethical approval.....	13
1.5 Research and Development Approval.....	13
2.0 Systematic reviews.....	15
2.1 Prevalence, incidence and nature of prescribing errors in hospital inpatients: a systematic review.....	15
2.2 The causes of and factors associated with prescribing errors in hospital in-patients: Systematic Review.....	16
2.3 What evidence is there that educational interventions reduce the risk of prescribing errors?.....	18
2.4 Discussion.....	18
3.0 Assessing the prevalence and type of prescribing errors.....	20
3.1 Introduction.....	20
3.2 Methods.....	20
3.3 Descriptive results.....	22
3.4 Regression analyses examining potential predictors of prescribing errors.....	31
3.5 Discussion.....	33
4.0 Understanding the causes of prescribing errors: Interviews with FY1 doctors.....	34
4.1 Introduction.....	34
4.2 Methods.....	34
4.2.1 Interviews with FY1 trainees.....	34
4.2.2 Interviews with curriculum leads.....	39
4.3 Results and discussion using Reasons theory of error.....	39
4.3.1 Skill-based errors: slips.....	44
4.3.2 Skill-based errors: memory lapses.....	51
4.3.3 Rule-based mistakes.....	54
4.3.4 Knowledge-based mistakes.....	61

4.3.5	Communication errors.....	70
4.3.6	Violations.....	74
4.3.7	Conclusion.....	75
4.4	Overarching themes.....	77
4.4.1	Prescribing support and workload.....	77
4.4.2	Prescribing pressure.....	79
4.4.3	Prescribing norms and culture.....	81
4.4.4	Following orders.....	82
4.4.5	Interaction with the environment.....	84
4.4.6	Safety nets.....	85
4.4.7	Interviewees' feelings about error.....	87
4.5	FY1 Doctors' views on their undergraduate training in prescribing and pharmacology and interviews with medical schools.....	89
4.5.1	Doctors' positive views of their education.....	90
4.5.2	Doctors' negative views of their education.....	95
4.5.3	Pharmacology versus prescribing.....	100
4.5.4	Doctors' thoughts on improving undergraduate medical courses.....	101
4.5.5	Examinations.....	108
4.5.6	Doctors' expectations.....	109
4.6	Transition from medical school to the FY1 year.....	111
4.7	Training within the FY1 year.....	116
4.8	Summary of doctors' views of their education and training.....	119
5.0	Discussion.....	122
5.1	Principal findings and meaning.....	122
5.2	Strengths and limitations of the research.....	129
5.3	Relationship to previously published research.....	130
6.0	Recommendations.....	132
6.1	Clinical working environments.....	132
6.2	Undergraduate medical education programmes.....	133
6.3	Foundation year one education.....	134
6.4	Other parts of the medical education continuum.....	135
6.5	Interprofessional education.....	135
7.0	Recommendations for future research.....	136

7.1 Clinical working environments.....	136
7.2 Undergraduate medical education programmes.....	136
7.3 Foundation year one education.....	136
7.4 Other parts of the medical education continuum and interprofessional education.....	137
8.0 References.....	138

Appendices

<i>Appendix A: Systematic review of the prevalence, incidence and nature of prescribing errors in hospital inpatients.....</i>	<i>141</i>
<i>Appendix B: The causes of and factors associated with prescribing errors: Systematic Review.....</i>	<i>178</i>
<i>Appendix C: Prevalence study data collection forms.....</i>	<i>206</i>
<i>Appendix D: Severity error classification scheme.....</i>	<i>208</i>
<i>Appendix E: FY1 trainee interview schedule.....</i>	<i>210</i>
<i>Appendix F: Curriculum lead interview schedule.....</i>	<i>215</i>

1.0 Introduction

In the tender document, the aim of the research was stated as to:

Explore the causes of prescribing errors made by FY1 doctors (first year foundation trainees), concentrating on the interplay between doctors' educational backgrounds and factors in the practice environment.

Key objectives were to:

1. Prepare a comprehensive literature review on the prevalence of prescribing errors
2. Measure the prevalence and nature of prescribing errors made by FY1 doctors from a range of educational backgrounds
3. Identify the contextual and antecedent causes of those errors, including issues of equality and diversity
4. Explore how those causes relate to the curricula of medical schools across the UK
5. Identify how revised medical education standards could minimise errors
6. Identify how further research could address prescribing errors made by other grades of doctor

Key activities of the project were stated as:

1. Project initiation meeting with the GMC to agree a detailed study design, project plan, deliverables and timescales
2. Application for ethics approval
3. Literature review
4. Study of prevalence of prescribing errors
5. Study of the causes of prescribing errors
6. Development of interventions and research frameworks
7. Analysis and reporting

1.1 The research team

- Dr Darren Ashcroft: Reader in Medicines Usage and Safety; Director, Centre for Innovation in Practice, School of Pharmacy and Pharmaceutical Sciences, University of Manchester.
- Professor Tim Dornan: Professor of Medicine and Clinical Education; Medical Education Research Group Leader, University of Manchester.
- Dr Heather Heathfield: Tribal Consulting, Manchester.
- Dr Penny Lewis: Post-doctoral Research Associate, Drug Usage and Pharmacy Practice group, School of Pharmacy and Pharmaceutical Sciences, University of Manchester.
- Dr David Taylor: Senior Lecturer in Medical Education and Honorary Fellow of the Centre for Excellence in Developing Professionalism, University of Liverpool.
- Dr Mary Tully: Clinical Senior Lecturer, School of Pharmacy and Pharmaceutical Sciences, University of Manchester.
- Professor Val Wass: Professor of Community Based Medical Education, University of Manchester.

1.2 Project roles and management

PL worked full time on the project supported closely by TD, MT and DA. The whole research team met fortnightly for project management meetings with frequent e-mail and verbal communication between those meetings. HH and colleagues from Tribal Consulting were represented at early project meetings. All project meetings were minuted to maintain an audit trail for all major decisions in the course of the project.

DA led on the part the study investigating the prevalence of prescribing errors. MT led the part of the study that investigated the causes of prescribing errors. Interviews with curriculum lead of the medical schools were led and conducted by DT and VW. The whole project was overseen by TD.

1.3 Project Advisory Group

The project advisory group met on four occasions during the course of the project. Members of the group included:

- Professor Dianne Parker: Professor of Applied Social Psychology, University of Manchester.
- Dr Gary Cooke: Consultant Epidemiologist, Stockport NHS Foundation Trust.
- Dr Mike Scott: Chief Pharmacist, Antrim Area Hospital, Northern Ireland
- Dr Graham Buckley: Former Chief Executive of NHS Education for Scotland and current Chair, Association for the Study of Medical Education.
- Dr Lesley Pugsley: Sociologist and Senior Lecturer in Medical Education, Cardiff University.

A senior medical student helped with the first systematic review and a medical student shadowing an FY1 doctor immediately before qualification attended one of the advisory meetings; her presence provided another means of validating the study methods and initial qualitative analysis.

1.4 Ethical Approval

Ethical approval was applied for in November 2007 and obtained in January 2008. A substantial amendment made in October 2008 for medical school curriculum leads to be interviewed was approved in November 2008; this substantial amendment was needed as we were unable to provide an interview schedule and other documentation at the time of the original ethical approval because these interviews were to be informed by the findings from the interviews with junior doctors.

1.5 Research and Development Approval

As well as ethical approval, research and development approval was required from 19 Acute NHS trusts. This involved the submission of all study

documentation, as well as additional documentation specific to individual Acute NHS Trusts, occupational health clearance and signatures of each Trust study-lead pharmacist and Chief Pharmacist. This whole process took up to two months in each of those hospital trusts.

2.0 Systematic reviews

Three systematic reviews were conducted as part of the study. The first explored the prevalence, incidence and nature of prescribing errors.¹ This has been published in Drug Safety and the abstract is given below. The full paper is included as Appendix A.

2.1 Prevalence, incidence and nature of prescribing errors in hospital inpatients: a systematic review

Abstract

Prescribing errors affect patient safety throughout hospital practice. Previous reviews of studies have often targeted specific populations or settings or did not adopt a systematic approach to reviewing the literature. Therefore, we set out to systematically review the prevalence, incidence, and nature of prescribing errors in hospital inpatients. MEDLINE, EMBASE, and International Pharmaceutical Abstracts (1985 - Oct 2007) were searched for studies of prescriptions for adult or child hospital inpatients giving enough data to calculate an error rate. Electronic prescriptions and errors for single diseases, routes of administration, or types of prescribing error were excluded, as were non-English language publications. Median error rate (interquartile range, IQR) was 7% (2-14%) of medication orders, 52 (8-227) errors per 100 admissions, and 24 (6-212) errors per 1000 patient days. Most studies (84%) were conducted in single hospitals and from the USA or UK (72%). Most errors were intercepted and reported before they caused harm although two studies reported adverse drugs events. Errors were commonest with antimicrobials and commoner in adults (median 18% of orders (10 studies, IQR 7-25%)) than children (median 4% (6 studies, IQR 2-17%)). Incorrect dosage was the commonest error.

Overall it is clear that prescribing errors are a common occurrence affecting 7% of orders, 2% of patient days and 50% of hospital admissions. However, the reported rates of prescribing errors varied greatly and this could be partly

explained by variations in the definition of a prescribing error, the methods used to collect error data and the setting of the study. Furthermore, a lack of standardisation between severity scales prevented any comparison of error severity across studies. Future research should address the wide disparity of data collection methods and definitions that bedevils comparison of error rates or meta-analysis of different studies.

A second systematic review was carried out into the causes of and factors associated with prescribing errors.² This was accepted for publication by Drug Safety and is currently in press. The abstract for the review is given below and the full paper is included as Appendix B.

2.2 The causes of and factors associated with prescribing errors in hospital in-patients: Systematic Review

Abstract

Prescribing errors are common, they result in adverse events and harm to patients and it is unclear how best to prevent them because recommendations are more often based on surmised rather than empirically collected data. This systematic review aimed to identify all informative published evidence concerning the causes of and factors associated with prescribing errors in specialist and non-specialist hospitals, collate it, analyse it qualitatively, and synthesise conclusions from it.

Seven electronic databases for the years 1985 to July 2008. The reference lists of all informative studies were searched for additional citations. To be included, a study had to be of handwritten prescriptions for adult or child in-patients and report empirically collected data on the causes of or factors associated with errors. Publications in languages other than English and studies that evaluated errors for only one disease, one route of administration, or one type of prescribing error were excluded.

Seventeen papers reporting 16 studies, selected from 1261 papers identified by the search, were included in the review. Studies from the USA and UK in university-affiliated hospitals predominated (10/16, 62%). The definition of a prescribing error varied widely and the included studies were not homogeneous enough or of a quality that supported quantitative analysis. Causes were grouped according to Reason's model of accident causation into active failures, error-provoking conditions, and latent conditions. The active failure most frequently cited was a mistake due to inadequate knowledge of the drug or the patient. Skills-based slips and memory lapses were also common. Where error-provoking conditions were reported, there was at least one per error, including lack of training or experience, fatigue, stress, high workload for the prescriber and inadequate communication between health-care professionals. Latent conditions included reluctance to question senior colleagues and inadequate provision of training.

Prescribing errors are often multifactorial, with several active failures and error-provoking conditions often acting together to cause them. In the face of such complexity, solutions addressing a single cause are likely to have only limited benefit. Further rigorous study of the causes of error needs to be conducted, seeking potential ways of reducing error. Multifactorial interventions across many parts of the system will likely be required.

A third, smaller review was then carried out to explore the evidence regarding the reduction of prescribing errors by educational interventions. Studies included in this review were selected from those studies included in the two previous reviews.

2.3 What evidence is there that educational interventions reduce the risk of prescribing errors?

Abstract

Aim

Identify evidence that could answer the question: How can educational interventions mitigate the risk of prescribing errors?

Method

Eighty informative publications from two systematic reviews into the prevalence and causes of prescribing errors were reviewed to identify studies that tested the impact of educational interventions.

Results

Just four papers contained informative evidence. Education was usually part of a complex intervention, including elements shown in continuing professional development research to be more effective at changing physicians' behaviour than education, such as systematic quality improvement, decision support, and 'at elbow' advice. All four were 'just in time' educational interventions; there was no evidence about the impact of basic medical education on prescribing errors.

Conclusions

What evidence there is suggests that 'just in time' education, as part of an intensive and complex intervention, can reduce prescribing errors, but poses more questions than it answers about the role of basic and systematic, post-basic education on prescribing errors and patient safety.

2.4 Discussion

These three systematic reviews support three main conclusions. First, it is clear that prescribing errors are common in that they affect 7% of orders, 2% of patient days and 50% of hospital admissions, although rates vary greatly from study to study. Second, that variation is partly explained by varied definitions of a prescribing error and partly by study methods which shows the need for better standardisation in future research. Third, prescribing errors are

usually multifactorial, with several active failures and error-provoking conditions acting together to cause them. We conclude that interventions to reduce prescribing errors that are aimed at addressing a single cause are likely to have only limited benefit.

3.0 Assessing the Prevalence and Type of Prescribing Errors

3.1 Introduction

The aim of this part of the study was to measure the prevalence and nature of prescribing errors made by FY1 trainees from a range of educational backgrounds. We originally proposed to undertake a prospective audit of prescribing errors in 14 Acute Hospital Trusts in the North West (including teaching and district general hospitals). FY1s trained in most UK medical schools were included since foundation trainees who started work in the two Deaneries in August 2007 came from a variety of medical schools. One Deanery provided us with information about the numbers of trainees from each medical school. This information revealed that, the 311 graduates represented 30 of the 31 medical schools.

3.2 Methods

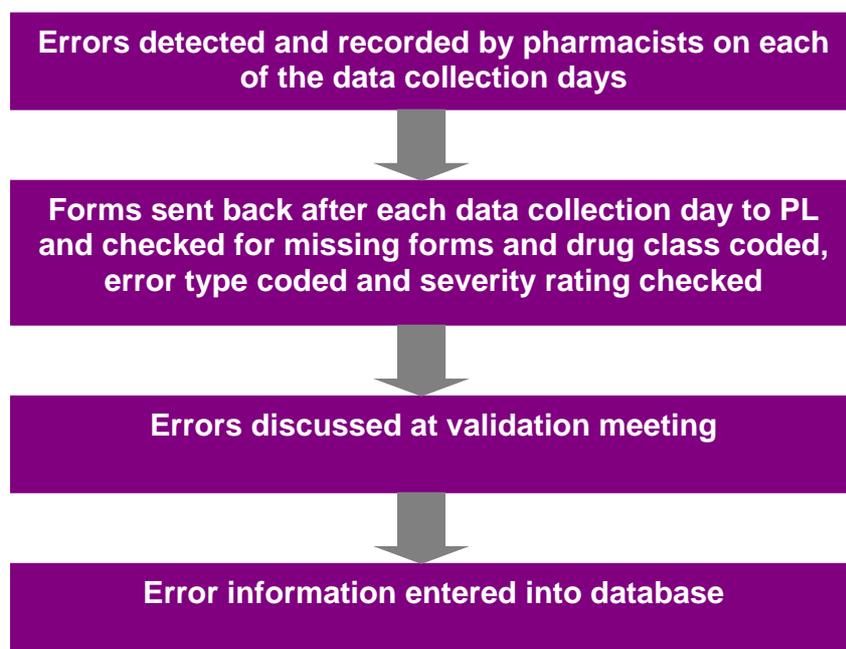


Figure 1: Prevalence study process

Data collection sites

Field work was completed in 19 hospital trusts (20 hospital sites) in North West England. That is higher than the original expected number of 14 trusts as additional hospitals volunteered to participate.

Data collection process

Pharmacists identified prescribing errors in all newly prescribed or written inpatient medication orders as part of their routine pharmacy practice. Data collection forms were designed and piloted at two hospital sites in January 2008. These forms are given in Appendix C. Severity ratings were developed from previous ratings used by Dean et al¹, Folli et al², Lesar et al³ and Tully et al⁴. A table of ratings and examples is given in Appendix D. Categories were minor, significant, serious, or potentially lethal. This was a rating of potential severity and not actual severity as most errors were corrected before patient administration. Data collection forms included a section for reporting actual patient harm, however, this was rarely completed and therefore analysis was not feasible.

Pharmacist training

Lead pharmacists from each of the trusts involved in the study attended two training sessions, each followed by a question and answer session, conducted by DA and PL. The lead pharmacists subsequently provided training and information at their hospitals to all pharmacists participating in the study, supported by an information leaflet providing detailed information on study requirements.

Data collection dates

Data were collected monthly in the participating hospitals on seven weekdays, two of which came after the date when new FY1 trainees took up their posts. Data collection was during pharmacists' day shifts, but included prescriptions written during the preceding hours.

Error validation panels

Two error validation panels were convened to assess the validity of the reported errors. Specifically, panels checked that each report represented a genuine prescribing error, checked the type of error that it represented and checked its severity. Panel members discussed each error until consensus was achieved. Each panel comprised two clinicians and two pharmacists. PL attended all meetings in order to moderate and establish consistency between panels. Each meeting was also minuted to keep each panel informed of decisions made by the other panel as well as their own. In order to process all errors, the panels met a total of 17 times for up to two hours at a time.

Data entry and analysis

Each error form was coded by PL and validated by the methods described above prior to data entry. A database was designed by Tribal Consulting.

Progress updates and feedback with hospital sites

The lead pharmacists from all hospital sites met quarterly and all meetings were attended by DA and PL. These meetings allowed any queries from pharmacists to be answered and updated participants on the progress of the study so they maintained a high level of engagement with the study throughout. Descriptive data have now been reported back to each individual hospital site.

3.3 Descriptive results

Descriptive results have been generated from the full data set. These are presented below:

In summary:

- 124,260 medication orders were checked
- 11,077 errors were detected
- The mean error rate was 8.9 errors per 100 medication orders
- Across all grades/types of prescriber, the mean rate of prescribing errors was 8.9% of medication orders

- 50,016 medication orders were written by FY1 doctors
- 4190 errors were detected on FY1 medication orders
- The rate of prescribing errors for FY1 doctors was 8.4%

Table 1: Error rates by prescriber and prescribing stage

Prescriber	Description	On admission	During stay	When drug chart re-written	TTA ¹ /Discharge Rx	Not known	Not given	NA	TOTAL
FY1	Orders written	14487	10365	7567	16271	342	624	360	50016
	Errors - number	1871	882	311	1038	18	46	24	4190
	Errors - %	12.9	8.5	4.1	6.4	5.3	7.4	6.7	8.4
FY2	Orders written	14297	7117	4011	8127	380	626	223	34781
	Errors - number	2175	611	130	546	34	50	22	3568
	Errors - %	15.2	8.6	3.2	6.7	8.9	8.0	9.9	10.3
FTSTA ² s	Orders written	6638	4968	1903	2782	173	200	170	16834
	Errors - number	785	312	90	163	13	17	11	1391
	Errors - %	11.8	6.3	4.7	5.9	7.5	8.5	6.5	8.3
NCCG ³ s	Orders written	1268	1447	820	622	120	111	7	4395
	Errors - number	141	80	30	37	3	8	1	300
	Errors - %	11.1	5.5	3.7	5.9	2.5	7.2	14.3	6.8
Consultants	Orders written	1037	1421	166	446	14	82	11	3177
	Errors - number	76	77	8	25	1	0	1	188
	Errors - %	7.3	5.4	4.8	5.6	7.1	0.0	9.1	5.9

¹ Medications 'to take away'; sometimes also known as TTO 'to take out'

² Fixed term specialty training appointments

³ Non consultant career grade staff

Prescriber	Description	On admission	During stay	When drug chart re-written	TTA ¹ /Discharge Rx	Not known	Not given	NA	TOTAL
Pharmacist	Orders written	12	35	0	131	1	0	0	179
	Errors - number	0	0	0	0	0	0	0	0
	Errors - %	0.0	0.0	0	0.0	0.0	0.0	0	0.0
Nurses	Orders written	440	336	30	114	16	26	15	977
	Errors - number	26	22	0	6	3	3	0	60
	Errors - %	5.9	6.5	0.0	5.3	18.8	11.5	0.0	6.1
Not known	Orders written	6317	3325	692	3009	214	207	137	13901
	Errors - number	899	210	30	186	11	21	23	1380
	Errors - %	14.2	6.3	4.3	6.2	5.1	10.1	16.8	9.9
Total	Orders written	44496	29014	15189	31502	1260	1876	923	124260
	Errors - number	5973	2194	599	2001	83	145	82	11077
	Errors - %	13.4	7.6	3.9	6.4	6.6	7.7	8.9	8.9

Table 2: Error severity by prescriber*

Potential severity	FY1		FY2		FTSTAs		NCCGs		Consultant		Pharmacist		Nurse		Not know		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Minor	1638	39.09	1400	39.24	571	41.05	148	49.33	87	46.28	0	0	27	45.00	556	40.29	4427	39.09
Significant	2253	53.77	1925	53.95	703	50.54	131	43.67	82	43.62	0	0	26	43.33	730	52.90	5850	52.90
Serious	220	5.25	187	5.24	89	6.40	16	5.33	17	9.04	0	0	4	6.67	74	5.36	607	5.36
Potentially lethal	79	1.89	56	1.57	28	2.01	5	1.67	2	1.06	0	0	3	5.00	20	1.45	193	1.73
TOTAL	4190	100.00	3568	100.00	1391	100.00	300	100.00	188	100.00	0	0	60	100.00	1380	100.00	11077	100.00

* Error severity categories are given in Appendix D

Table 3: Types of medications associated with errors

BNF⁴ category	Drug type	Errors no.	Errors %⁵
4.7	Analgesics (opioid and non-opioid)	1073	9.7
5.1	Antibacterial drugs	685	6.2
3.1	Bronchodilators	626	5.7
2.6	Nitrates, calcium channel blockers and other antianginal drugs	588	5.3
3.2	Corticosteroids	538	4.9
1.3	Antisecretory drugs and muscosal protectants	427	3.9
2.8	Anticoagulants	376	3.4
2.5	Hypertension and heart failure	375	3.4
2.12	Lipid-regulating drugs	371	3.3
2.2	Diuretics	347	3.1
6.1	Drugs used in diabetes	347	3.1
2.9	Antiplatelet drugs	343	3.1
9.6	Vitamins	336	3.0
4.3	Antidepressants	331	3.0
4.6	Drugs used in nausea and vertigo	330	3.0
1.6	Laxatives	289	2.6
10.1	Drugs used in rheumatic diseases and gout	261	2.4
9.1	Anaemias and other blood disorders	255	2.3
6.6	Drugs affecting bone metabolism	237	2.1
9.5	Minerals	229	2.1
N/A	Not given	219	2.0
4.1	Hypnotics and anxiolytics	195	1.8
2.4	Beta blocking drugs	188	1.7
4.8	Antiepileptics	184	1.7
6.3	Corticosteroids	171	1.5
11.6	Treatment of glaucoma	145	1.3
6.2	Thyroid and antithyroid drugs	113	1.0
9.2	Fluids and electrolytes	112	1.0
4.2	Drugs used in psychoses and related disorders	95	0.9
7.4	Drugs used for genito-urinary disorder	86	0.8
3.4	Antihistamines and allergic emergencies	81	0.7
10.2	Drugs used in neuromuscular disorders	72	0.6
11.8	Misc ophthalmic preparations	71	0.6
2.1	Positive inotropic drugs	69	0.6

⁴ British National Formulary

⁵ This number refers to the percentage of errors of all errors detected. The denominator for each class of drug was not known

BNF⁴ category	Drug type	Errors no.	Errors %⁵
12.3	Drugs acting on the oropharynx	66	0.6
12.2	Drugs acting on the nose	51	0.5
6.4	Sex hormones	50	0.5
16	Nutrition	45	0.4
1.2	Antispasmodics	42	0.4
4.10	Drugs used in substance dependence	41	0.4
4.9	Drugs used in parkinsonism and related disorders	41	0.4
1.1	Dyspepsia and GORD ⁶	35	0.3
13.2	Emollient and barrier preparations	32	0.3
13.4	Topical corticosteroids	32	0.3
2.3	Anti-arrhythmic drugs	28	0.3
1.5	Chronic bowel disorders	27	0.2
15.1	General anaesthesia	25	0.2
3.7	Mucolytics	25	0.2
1.9	Drugs affecting intestinal secretions	24	0.2
11.4	Corticosteroids and other anti-inflammatory preparations	23	0.2
17	Misc	23	0.2
5.2	Antifungal drugs	22	0.2
1.4	Acute diarrhoea	21	0.2
5.3	Antiviral drugs	21	0.2
11.3	Anti-infective eye preparations	20	0.2
13.10	Anti-infective skin preparations	20	0.2
13.11	Skin cleansers and antiseptics	20	0.2
8.3	Sex hormones and hormone antagonists in malignant disease	18	0.2
2.7	Sympathomimetics	15	0.1
8.1	Cytotoxic drugs	14	0.1
4.11	Drugs for dementia	13	0.1
3.3	Cromoglicate, related therapy and leukotriene receptor antagonists	10	0.1
10.3	Drugs used for soft-tissue inflammation	9	0.1
6.5	Hypothalamic and pituitary hormones and anti-oestrogens	9	0.1
8.2	Drugs affecting the immune reponse	9	0.1
12.1	Drugs acting on the ear	8	0.1
7.3	Contraceptives	8	0.1
13.5	Preparations for eczema and psoriasis	7	0.1
11.5	Mydriatics and cycloplegics	6	0.1
4.5	Drugs used for obesity	6	0.1
1.7	Anal and rectal disorders	5	0.0

⁶ Gastro-oesophageal reflux diseases

BNF⁴ category	Drug type	Errors no.	Errors %⁵
7.2	Treatment of vaginal and vulval conditions	5	0.0
13.3	Topical local anaesthetics and antipruritics	4	0.0
15.2	Local anaesthesia	4	0.0
18	Dressings	4	0.0
3.9	Cough preparations	4	0.0
9.3	Intravenous nutrition	4	0.0
2.11	Antifibrinolytic drugs haemostatics	3	0.0
13.9	Preparations for scalp and hair conditions	2	0.0
14.4	Vaccines and antisera	2	0.0
6.7	Other endocrine drugs	2	0.0
9.8	Metabolic disorders	2	0.0
2.10	Myocardial infarction and fibrinolysis	1	0.0
3.10	Nasal decongestants	1	0.0
4.4	CNS stimulants and drugs for ADHD ⁷	1	0.0
5.4	Antiprotozoal drugs	1	0.0
7.1	Drugs used in obstetrics	1	0.0
TOTAL		11077	100.0

⁷ Attention deficit hyperactivity disorder

Table 4: Types of error reported

Error type	Errors No.	Errors %
Omission on admission	3272	29.8
Underdose	1221	11.1
Overdose	936	8.5
Strength/dose missing	815	7.4
Omission on TTA	678	6.2
Administration times incorrect/missing	664	6.1
Duplication	598	5.5
Product/formulation not specified	420	3.8
Incorrect formulation	401	3.7
No maximum dose	392	3.6
Unintentional prescription of drug	342	3.1
No signature	187	1.7
Clinical contra-indication	119	1.1
Incorrect route	108	1.0
No indication	108	1.0
IV instructions incorrect/missing	101	0.9
Drug not prescribed but indicated	92	0.8
Continuation for longer than needed	84	0.8
Route missing	93	0.8
Start date incorrect/missing	81	0.7
CD requirements incorrect/missing	50	0.5
Drug interaction	58	0.5
Daily dose divided incorrectly	49	0.4
Significant allergy	37	0.3
Continuation after ADR	24	0.2
Premature discontinuation	21	0.2
Drug interaction not taken into account	14	0.1
No dosage alteration after levels out of range	6	0.1
Dose/rate mismatch	1	0.0
TOTAL	10972	100.0

3.4 Regression analyses examining potential predictors of prescribing errors

Univariate and multi-variate regression models were developed to examine the potential impact of the type of prescriber, type of prescription (handwritten versus electronic) and the stage of the hospital stay when the medication order was issued on the likelihood of a prescribing error occurring; all models were also adjusted for clustering by hospital site, as shown in Table 5.

After controlling for the type of prescriber, prescribing stage and type of prescription, there were significant differences for all three explanatory variables. The multivariate model indicated that there were significantly higher rates of prescribing errors for all grades of doctor when compared against consultant prescribing error rates, with Foundation Year 1 (adjusted odds ratio (OR) 2.13 95% CI 1.80 – 2.52) and Foundation Year 2 (adjusted OR 2.23 95% CI 1.89 – 2.65) practitioners being more than twice as likely to prescribe erroneously than consultants. There were no significant differences identified for prescribing error rates by pharmacist (adjusted OR 0.84 95% CI 0.36 – 1.93) or nurse prescribers (adjusted OR 1.00 95% CI 0.71 – 1.39) when compared against consultant prescribing error rates.

Likewise, the stage of the hospital stay was also found to be an important predictor of the likelihood of prescribing errors after controlling for the type of prescriber and the type of prescription. Medication orders issued at the time of hospital admission were 70% more likely to be associated with a prescribing error (adjusted OR 1.70 95% CI 1.61 – 1.80) in comparison to medication orders issued during the hospital stay. In contrast, prescribing errors were 52% less likely (adjusted OR 0.48 95% CI 0.43 – 0.52) on drug charts that were rewritten and 23% less likely on discharge prescriptions (adjusted OR 0.77 95% CI 0.72 – 0.82) than medication orders issued during the hospital stay. Electronic prescriptions were also 12% less likely to be associated with a prescribing error than handwritten prescriptions after

controlling for type of prescriber and the prescribing stage when the medication order was issued.

Table 5: Results of univariate and multi-variate regression analyses of potential predictors of prescribing errors

Variable	Univariate analysis OR (95% CI)†	Multivariate analysis OR (95% CI)†
Prescriber		
Consultant	Reference	Reference
FY 1	1.90 (1.61 – 2.24)	2.13 (1.80 – 2.52)
FY 2	2.24 (1.90 – 2.65)	2.23 (1.89 – 2.65)
FTSTA	1.89 (1.59 – 2.24)	1.84 (1.54 – 2.19)
NCCG	1.42 (1.16 – 1.75)	1.58 (1.29 – 1.94)
Pharmacist	0.55 (0.24 – 1.27)	0.84 (0.36 – 1.93)
Nurse	1.15 (0.83 – 1.58)	1.00 (0.71 – 1.39)
Prescribing stage		
Inpatient prescription	Reference	Reference
Admission	1.83 (1.74 – 1.93)	1.70 (1.61 – 1.80)
Rewrite drug chart	0.51 (0.47 – 0.56)	0.48 (0.43 – 0.52)
Discharge prescription	0.82 (0.77 – 0.88)	0.77 (0.72 – 0.82)
Type of prescription		
Handwritten	Reference	Reference
Electronic	0.87 (0.79 – 0.95)	0.88 (0.79 – 0.97)

† adjusted for clustering by hospital site

3.4 Discussion

The total mean error rate for all medication orders was 8.9%, consistent with previous publications.^{1;3} Other studies found that junior doctors made more errors than other prescribers;^{4;5} however, they did not take into account the number of prescriptions written. The rate of prescribing errors made by FY1 doctors was similar to (more experienced) FTSTAs and it was FY2 doctors who had the highest error rate of all. Our regression analyses showed that FY1 and FY2 doctors were twice as likely as consultants to make a prescribing error. Our model also revealed that new prescribers (i.e. nurses and pharmacists) had similar error rates to consultants. This is the first study to report on the comparative safety of non-medical prescribers. So, prescribing errors are not simply an issue for undergraduate education. If education is to be the solution, it must also include postgraduate and continuing education.

Prescribing errors were 70% more likely on admission. This finding strongly supports the medicines reconciliation initiative set out by the National Patient Safety Agency and the National Institute for Health and Clinical Excellence.⁶

The majority of errors were deemed potentially significant (53%) or potentially minor (40%). Potentially serious errors were less common (5%) and potentially lethal errors were found in fewer than 2% of erroneous medication orders. It is important to stress that those figures are a measure of potential severity and not actual severity as pharmacists detected most errors before they affected patients.

4.0 Understanding the Causes of Prescribing Errors: Interviews with FY1 doctors

4.1 Introduction

This part of the study set out to explore the causes of prescribing errors, since very little is known about the impact of basic medical education, with particular reference to deficiencies in basic medical education. We took an in depth qualitative approach.

4.2 Methods

4.2.1 Interviews with FY1 trainees

Many previous studies into the causes of prescribing errors are based on the supposition of researchers.² We chose to conduct interviews using the critical incident technique⁷ to collect empirical data, which albeit depending on self-report, pertained to causes elicited by interviews with prescribers who had actually made a prescribing error.

The interviews were in two parts; first a critical incident debrief on one or more specific errors and then a discussion of education. An interview schedule derived from the critical incident technique was developed and is given in Appendix E. Participating FY1 trainees were asked before their interview to identify any prescribing errors that they remembered making. These errors were then explored, asking specifically about:

- The nature of the error(s)
- The situation in which it was made.
- Reasons for making it.
- The respondent's attitudes towards it

If the participant had more than one error, they were discussed in the respondent's order of preference. The second part of the interview schedule asked interviewees about their experiences of and attitudes towards basic medical education. It explored their attitudes towards the teaching about prescribing they had received at medical school, their experiences of training received in their current post, and the safety culture of their FY1 hospital.

Sampling and recruitment

Recruitment of FY1 doctors was by email via foundation administrators within the Manchester and Mersey Deaneries. Due to a low initial response rate, short recruitment presentations were also given at ten hospital trusts.

Purposive (as opposed to representative) sampling of interviewees ensured a 'maximum variability' sample of FY1 doctors. One of our objectives was to identify the contextual and antecedent causes of errors, including issues of equality and diversity. Therefore we ensured that our sample included doctors of varying ethnicity from a variety of medical schools and both genders.

Doctors were chosen from a variety of different hospitals.

Analysis

Data were analysed by the constant comparison method, and a coding framework was developed based on interviewees' words and phrases. Data analysis was interspersed between data collection so each was informed by the other within an iterative study design. Triangulation of the data from interviews with the FY1 doctors with the curriculum lead interviews (described in section 4.2.2) was also carried out during the analysis.

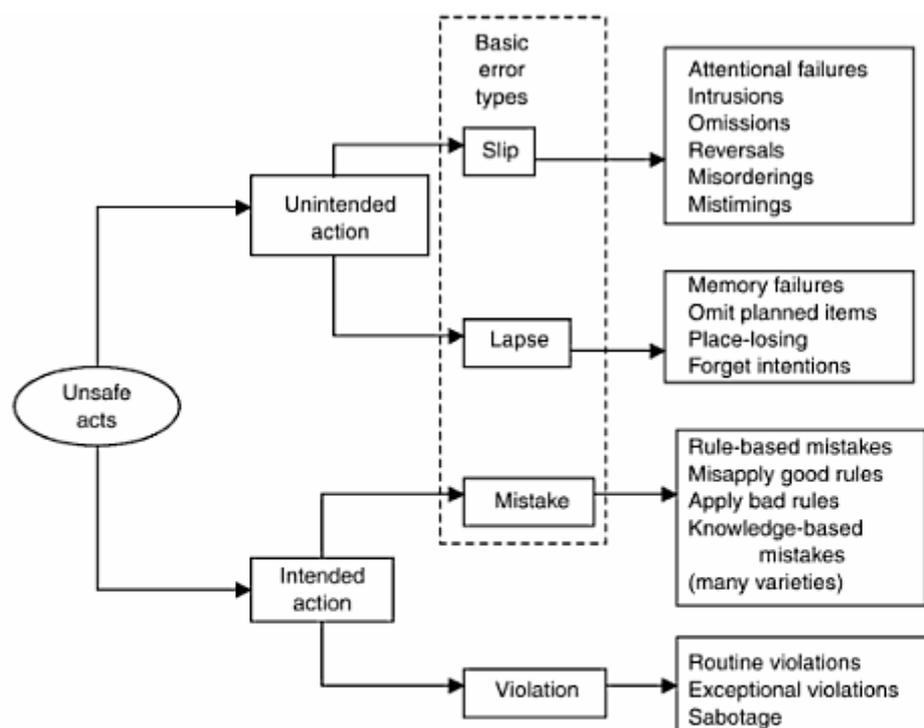
Reason's model of accident causation⁸ was used to categorise and present the data. This is the most commonly used theoretical model when considering prescribing errors⁹⁻¹² and it was thought that use of it would make it easier to link our findings with previous publications. A brief explanation of this model is given below.

James Reason categorised errors into two main types; those that occur with the failure of execution of a good plan and those that arise from correct execution of an inappropriate or incorrect plan. The former are termed slips or lapses. Slips occur when performing an action, such as writing a prescription for carbimazole when carbamazepine is wanted and these occur due to attentional failures. Memory lapses, unlike slips, are errors due to omission of a particular task. Slips and lapses occur at what has been termed the skill-based level of performance and occur during what are often automatic and routine tasks requiring little cognitive input.

Errors that occur due to the correct execution of an inappropriate or incorrect plan are termed mistakes. These mistakes are of two types; rule-based mistakes (RBMs) and knowledge-based mistakes (KBMs). RBMs occur when the person making the error has some familiarity of the task at hand due to experience or training and can draw on rules that he or she has applied in the past. Mistakes occur when a normally good rule is misapplied, such as the failure to spot that a patient has a contraindication to a particular treatment. They can also occur when the rule applied is a bad rule or when individuals fail to apply a good rule.

KBMs take place at a higher conscious thought processing level. These occur when the person performing a task has to consciously think about how to carry out the task. This level of performance is used when a task is novel to the person and they have no previous stored rules that they can apply to carry out the task.

Slips, memory lapses, RBMs and KBMs are all unintentional errors. When deviations from normal rules and procedures are intentional then these are termed violations. Violations are often related to motivation and work environment. Three types of violations are discussed by Reason.⁸ These are; routine violations which occur when individuals believe that they have enough skill to break rules and this can be done in order to save time; situational violations, occurring when the local environment makes following the rules difficult or impossible; Optimising violations, which occur for personal gain, such as deciding to break a rule to demonstrate skill at a particular task.¹³



Summary of main error types

Slips — skill-based, actions not as intended, perpetrator unaware, task-execution failures

Lapses — skill-based, unconscious mental errors, perpetrator may become aware of later, storage-stage (memory) failures

Mistakes — rule- or knowledge-based, perpetrator unlikely to be aware of unless deliberate (violations), planning-stage failures

Violations — deliberate deviations from standard practice, carried out to maintain safe operation

Fig 2: Human error types (J Reason 1990, Human Error⁸)

Figure 2 depicts the different types of unsafe acts implicated in an error. Unsafe acts, although at the sharp end of errors, are not the sole causal factor. The systems perspective of error¹⁴ looks at how other factors in the environment can impact on the possibility of errors arising. Figure 3 depicts this systems perspective and shows the path that an error takes, including not only the active failures or unsafe acts but also latent conditions (e.g. organisation processes) and error-provoking conditions (e.g. environmental factors).

Latent conditions

Organisational processes- workload, handwritten prescriptions
Management decisions- staffing levels, culture of lack of support for junior staff

Error-producing conditions

Environmental – busy ward
Team- lack of supervision
Task- poor medication chart design
Patient- complex, communication difficulties

Active failures

Slip, lapse, rule-based mistake, knowledge-based mistake

Defences

Inadequate, unavailable, missing

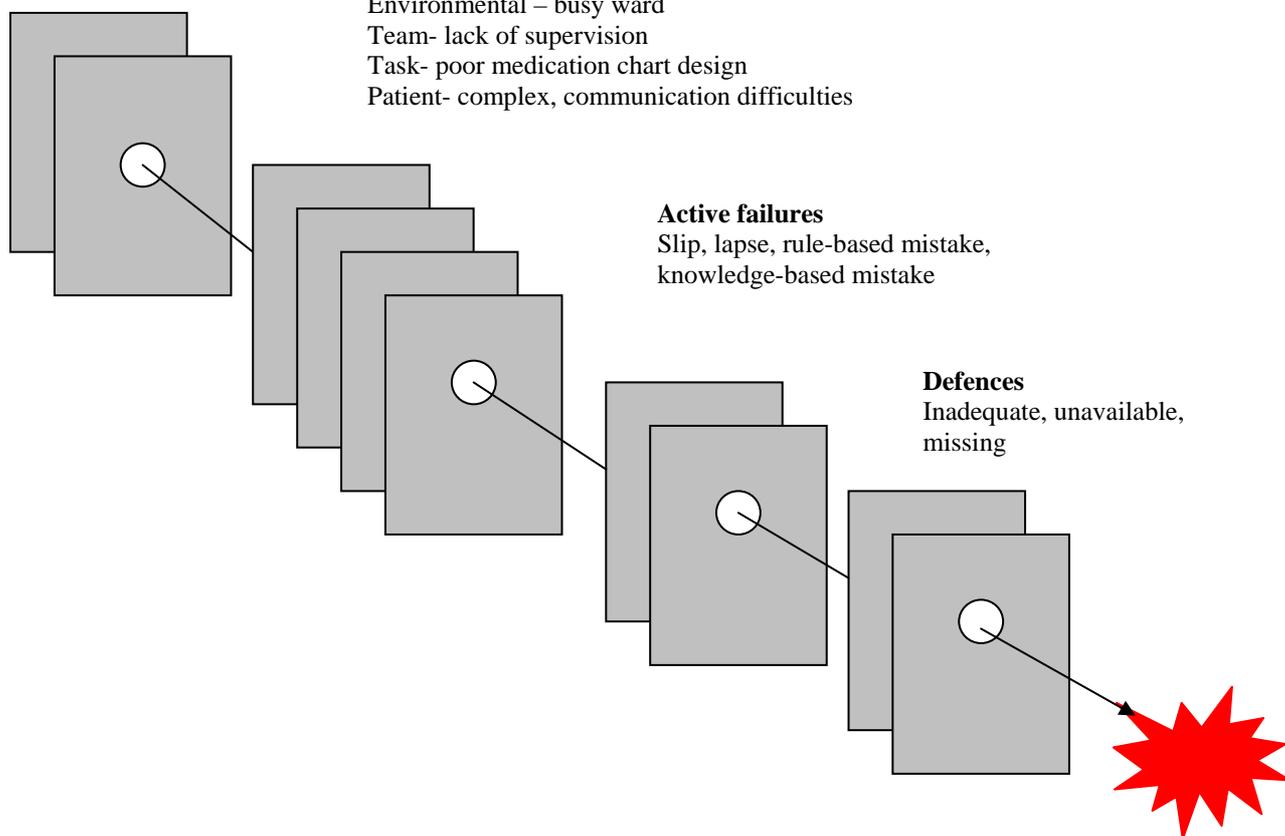


Figure 3: Incident analysis framework modified from Coombes et al¹⁵

In our analysis we grouped errors by the ‘unsafe acts’ or ‘active failures’ that doctors discussed. We then explored the error-producing conditions and latent conditions associated with each error, depicting the factors in a diagram. This led to the formation of an overall model of the different types of errors, according to Reasons framework.

Potential severity.

As with the prevalence study, a validation panel was set up to assess the potential severity of the reported errors using the same technique described previously (see section 3.2).

4.2.2 Interviews with curriculum leads

To place the above interview data in the wider context of respondents' basic medical education, brief telephone interviews with curriculum leads of their medical schools were also conducted. The methods of this stage of the study are given below.

The interview schedule

The interview schedule for the telephone interviews is given in Appendix F. This schedule refined by discussion with members of the expert reference group, covered areas the type of programme provided to students, elements of the course that covered prescribing, interdisciplinary teaching, assessments and feedback. Also, importantly, it asked whether interviewees believed that their curriculum prepared students for prescribing and whether it had any gaps.

Sampling and Recruitment

During the course of the interviews with FY1 doctors, we established the medical schools from which they had graduated. The curriculum leads in each of those medical schools were identified and approached with a view to participating in this study.

Analysis

Thematic analysis was carried out with data collected from the curriculum leads. These data were then used to triangulate key themes that emerged from the interviews with FY1 trainees.

4.3 Results and Discussion

In total, 68 FY1 doctors returned recruitment questionnaires, from whom 30 were selected. Those interviews covered graduates from 18 of the UK's 31 medical schools. Fourteen doctors worked in a teaching hospital trust and 16 worked in a district general hospital at the time of the interview. They are from 17 different hospital sites, representing over half of the 29 hospital trusts in the North-West. Interviewees' comments have been anonymised to maintain

the confidentiality of both the FY1 trainee and their medical school. The sample of FY1 trainees included 14 men and 16 women. Five interviewees were of Asian ethnicity, two of black ethnicity, and the remainder of white ethnicity. All except one participant was British; one participant was an EU student. Seven interviewees had come through graduate entry programmes. These frequencies were approximately representative of the FY1 cohort.

Table 5 gives the number of FY1 doctors interviewed from each medical school. Individual codes are not assigned in this table so as to ensure anonymity for both the medical school and the interviewee.

Table 6: No. of interviewees from each medical school

Medical School	No. of interviewees
Aberdeen	1
Barts and the London	2
Birmingham	1
Bristol	1
Cambridge	2
Dundee	1
Edinburgh	2
East Anglia	2
Hull	1
Imperial college	2
Keele	1
Liverpool	3
Manchester	4
Newcastle	1
Nottingham	1
Queens Belfast	1
Sheffield	2
St Andrews/ Manchester	1
Warwick	1

Table 7: Interviewee codes, current speciality and length of time as FY1 trainee

Interview code	Current speciality	Time in FY1 post
1	Endocrinology	11 months
2	Endocrinology	11 months
3	Cardiology	7 weeks
4	Cardiology and general medicine	7 weeks
5	Paediatrics	9 weeks
6	Colorectal surgery	9 weeks*
7	Obstetrics and gynaecology	9 weeks
8	General surgery	12 weeks
9	Psychiatry	12 weeks
10	Colorectal surgery	13 weeks
11	Respiratory medicine	17 weeks
12	Orthopaedics and trauma	17 weeks
13	Orthopaedics	5 months
14	Surgery	5 months
15	Diabetes	5 months
16	Rheumatology	6 months
17	Orthopaedics	6 months
18	Breast surgery	6 months
19	Vascular surgery	6 months
20	Gastroenterology	6 months
21	Elderly medicine	6 months
22	Haematology	7 months
23	Surgical high dependency	7 months
24	Acute medicine	7 months
25	Geriatrics and general medicine	8 months
26	Nephrology	8 months
27	Endocrinology	9 months
28	Gastroenterology	9 months
29	General surgery	9 months

30

General surgery

10 months

* had been a locum doctor the previous year

Interviews with curriculum leads

All schools accepted the invitation to take part in a telephone interview. In some schools, the curriculum leads nominated an alternative interviewee who was more familiar with the detailed delivery of the pharmacology and therapeutics curriculum. The average length of interview was 22 minutes. Each medical school was assigned a letter from A- R and these are used in subsequent quotations.

Interviews with FY1 trainees

All interviewees discussed errors made since starting their posts. One interviewee (Int 6) had done locums before starting the FY1 year and also drew on events from that time. Interviews took place from July 08 to May 09, so interviewees were at varying stages of the FY1 year.

Interviewees had varying notions of what a prescribing error was. On commencing the interview, a few doctors could not remember making any prescribing errors. However, reflection during the interview and prompting about interactions with pharmacists led all interviewees to recall at least one prescribing error, some reporting up to eight. Their initial difficulty remembering errors suggests they were not especially anxious about errors nor did they find prescribing overly problematic.

Interviewees strongly suspected they had made more errors than they actually knew about. This issue was often discussed during recruitment presentations, when potential recruits said they felt sure that they had made errors but didn't actually know what they were and therefore it might be hard to discuss them in a research interview. The topic of feedback is discussed in detail in section 4.5 regarding FY1 doctors' views of their training.

When interviewees were asked to recall prescribing errors, they often distinguished between 'silly' errors and more serious errors. Those that were categorised as 'silly' included prescribing statins during the day instead of at

night; serious errors were generally related to errors in dosage. Errors that were perceived as 'silly' could also result from a doctor's conscious decision to overlook some aspect of prescribing, leading to what could be described as a 'violation'. This type of error usually resulted from a heavy workload under time pressure, a situation discussed in greater detail in section 4.4.1.

Altogether, respondents reported 85 prescribing errors during the interviews, including 'silly' errors and ones felt by interviewees to be more serious, errors that had been deliberate (i.e. violations) and non-deliberate, and ones that interviewees did not regard as prescribing errors at the start of the interview.

Reason's theory of error causation

Reason's theory of error allowed some initial categorisation of errors. As outlined in Methods, the active failures of each incident were identified and classified as either knowledge-based errors, rule-based errors or the skill-based memory lapses and slips. Eighteen errors were mainly due to a knowledge-based mistake, 34 were due to a rule-based mistake, 23 were mainly due to slips or lapses and three were direct violations. A further seven incidents were related to receipt of incorrect information and therefore were not the active failure of the respondent but of another individual (these individuals included patients, nurses and other doctors). Therefore, these errors did not fit into one of Reason's categories and were given their own category, communication errors.

The potential severity of prescribing errors ranged from minor errors, such as not signing a prescription to more serious errors such as prescribing penicillin to a patient who was allergic. The distribution of severity ratings was similar for the four active failure types (KBMs, RBMs, skill-based slips and skill-based lapses).

The following sections discuss each type of active failure separately. A descriptive analysis of the common events leading up to each type of active failure is provided for each of them.

Each active failure had various error-provoking conditions and latent conditions predisposing to it. Detailed analysis of these conditions is shown as pictorial diagrams. These depict each active failure and its associated error-producing conditions and latent conditions (each individual error/critical incident has a unique number which can then be traced through the diagrams). These diagrams highlight one of our main findings, which was that errors were rarely due to a single causal factor, a finding which was consistent with the results of our systematic review into the causes of prescribing errors.²

4.3.1 Skill-based errors: slips

Skill-based slips were discussed by several FY1 trainees during the interviews. Figure 4 depicts the various error producing conditions and latent conditions associated with 12 such slips, just one of which (incident number 44) impacted on a patient.

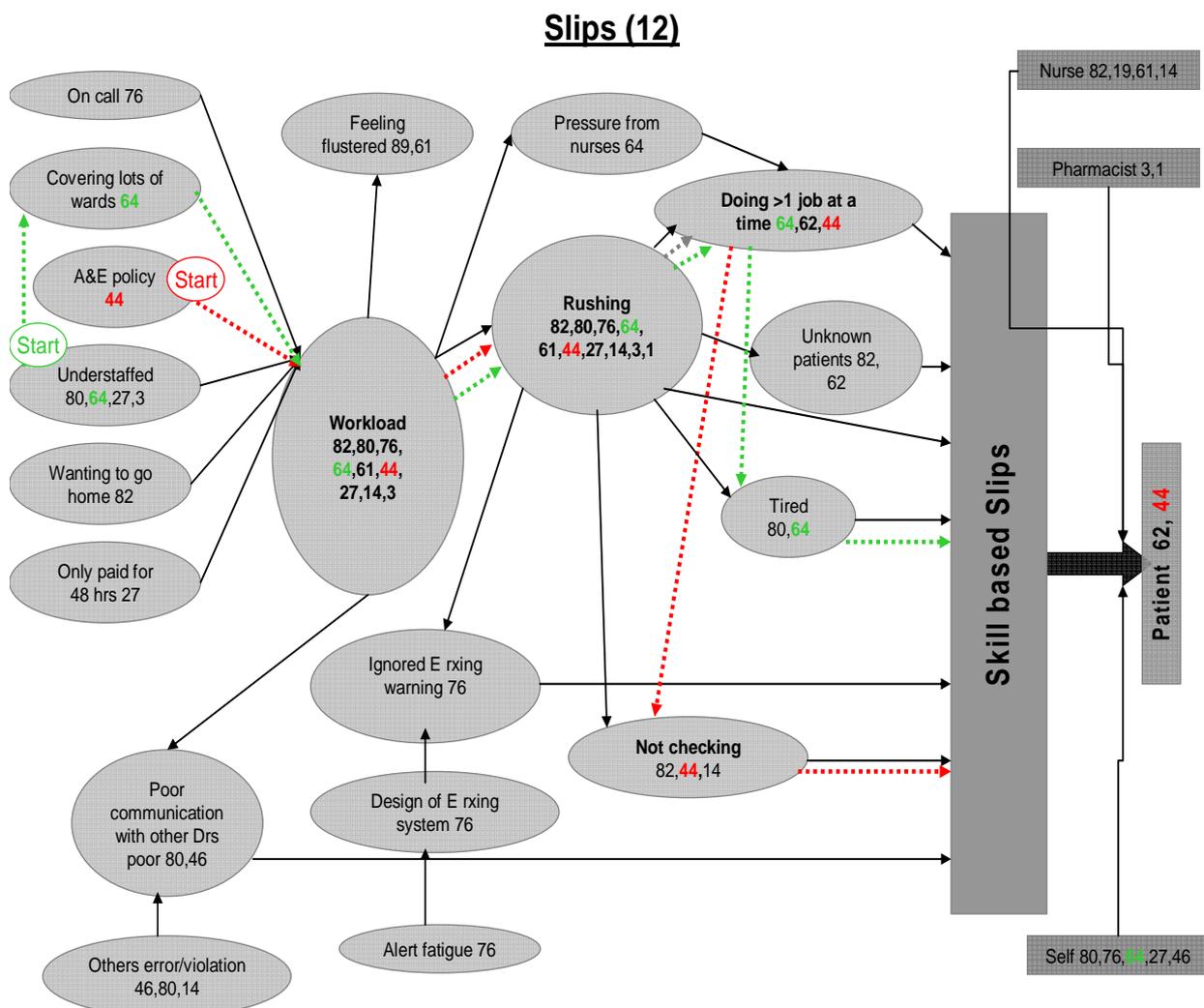


Figure 4: Factors implicated in the formation of skill-based slips. The numbers in each circle relate to the number given to each critical incident. Two examples of errors are highlighted in the diagram by the red and green arrows (errors 44 and 64).

Doctors' most common slips were dosage errors, especially wrong unit errors:

"...I think it was something like 400 milligrams – erm, but then I was called back, erm, because the dose that I'd prescribed didn't come in that amount of vials....and when I re-prescribed it I prescribed it as, as, like, 400 grams IV so I've made a massive, massive dose error" Interviewee 21 (medical school C)

Prescribing for the wrong patient and errors of duplication were the other main types of slip. Rushing was the predominant reason given by doctors for errors of this nature. The doctor quoted below described how he had made a slip by writing the dose of a drug in milligrams instead of micrograms, despite setting out to prescribe the latter; his only explanation was that he was in rush:

"It wasn't so much a mistake in what I wanted to write, but a mistake in what I wrote. So such as digoxin is something done in micrograms, and I know right in the beginning, erm, when I started prescribing, I knew it was micrograms, but... I was in a rush and I wrote milligrams. Erm, and then the Pharmacist checked that and said, "Did you mean micrograms?" I said, "Yeah of course I did," and corrected that" Interviewee 1 (Medical school C)

Respondents most often cited a high workload as the cause of their hurriedness. This error provoking condition was explored in greater detail with some interviewees; many felt that too many patients and not enough staff was the main reason for their excessive workload:

"...that team has far too, there's just, there's no way you can do that job from the allocated hours that they give." Interviewee 28 (medical school N)

This same interviewee worked in a team in which one of the other FY1 trainees had been sacked and not replaced, leaving him with a greater proportion of the workload:

"...one of our doctors got sacked, there's meant to be five house officers and one of them got sacked and never got replaced." Interviewee 28 (medical school N)

A lack of sufficient numbers of medical staff meant that some doctors had to cover more than their normal number of wards. This was a particular problem on night shifts and the doctor quoted below discussed how, at the time of making a prescribing error, he had no senior support:

"Q: And why do you think you made that error?"

A: Erm, just hassle, I'd say. Mainly because when I, it was on nights, erm, and I was the only House Officer on, er, because the SHOs for, this is surgical nights, erm, cos the SHO, for [name of ward] and for the wards, had both phoned in sick. Erm, and so the SHO we had covering was doing it more on a locum basis and was stuck down in A and E, so I had no senior support"

Interviewee 22 (medical school O)

Another doctor working in orthopaedics, felt that the number of patients that he had to prescribe for was excessively high and that this was a factor in the repeated slips that he had made when prescribing on the electronic prescribing system:

"Quite often there was a situation where there was just me prescribing for 60 patients, with a, quite a fast turnover." Interviewee 1 (medical school C)

One slip, which involved the mixing up of two patients in the A & E department, resulted in both patients being given the wrong medications. When the doctor recounted the incident she felt that she had been flustered as she was so busy:

“I was just flustered at the time there was just so many things to do and I was trying to, I think the flucloxacillin patient, I was stitching a wound up so I prescribed flucloxacillin for the other patient inadvertently and the diclofenac was for somebody who had come in with a pain in the back. Cos I was trying to deal with them both at the same time.” Interviewee 30 (medical school L)

On further exploration of the causes of this error, she revealed how the time constraints within the A&E department meant that she had to try to do two jobs at once. This may then have led to her selecting the wrong patients on the electronic prescribing system and also, most importantly, not to check her actions:

“I can remember at the time being really just, really stressed cos I was trying to stitch the wound upon the patient’s finger and then cos of the time constraints in A&E, I was trying to get rid of the other patient that I had...”
Interviewee 30 (medical school L)

Doing more than one job at a time was a causal factor in other respondents’ errors; one of which was influenced by pressure from nursing staff to prescribe:

“...the nursing practitioners were just sending jobs and jobs and jobs my way... when I tried to do things like rewrite a drug chart, I'd have people arriving on the wards saying, “Okay, I've just got fluids for this chart and I've got the Us and Es,” or they'd bring four or five charts with them all with things to be done. And so I'd get distracted and I'd come away from what I was doing. I couldn't, they wouldn't let me finish, getting, sort of, standing, tapping... So I think it was basically time pressure and, and trying to do, trying to multitask...” Interviewee 22 (medical school O)

Other explanations given for rushing included *“trying to do it [prescribe] quickly before I went home”* Interviewee 28 (medical school N)

The doctor quoted above also felt that there was too much work to be completed in the time available and he commented on how he was only paid to work for 48 hours compared to previously when he would have been paid for 60 hours. This led him to try and complete the work in the allotted time:

"I used to work sixty hours a week on...and we only used to get paid for forty eight so it was just, everything had to be done fast." Interviewee 28 (medical school N)

Not all rushing was attributable to external factors and some doctors rushed because they felt that the task of prescribing was quite tedious. Writing discharge prescriptions and transcribing drug charts were particularly boring tasks:

"I suppose there's probably a degree of just mental fatigue and that, and also maybe a bit of boredom, you know, if it's just, like... It isn't the most exciting task ever, writing out what drugs on a drugs card, it is pretty boring, erm, and if you're doing it a lot through the afternoon, you just tend to try and get through it as quickly as you can." Interviewee 2 (medical school H)

Working at an increased pace and feeling under pressure, mentally and physically, made doctors feel flustered and this emotion was a factor in some prescribing errors:

"I think I made that error probably because I was flustered and had to run all the way to Gynae to do it, and secondly just sheer inattention, I think."
Interviewee 21 (medical school C)

Feeling tired at the time of the error due to working on-call or working long hours was also an error producing condition discussed by some interviewees. This doctor felt that his tiredness had led him to write up the same drug twice on a prescription chart:

“...so third night in, quite tired, erm, and, I mean, on nights as well, I didn’t get any breaks either, no natural breaks....I was on the go from when I got there at 8.45 at night through to 8 in the morning continually. Er, I didn’t get a drink, didn’t get a wee or anything. Erm, so... Yeah. So I didn’t, I didn’t have that sort of automatic reflex, “Oh, I’ve written this before.” I just, sort of, almost, sort of, automatically transcribed it, I think.” Interviewee 22 (medical school O)

A couple of doctors also discussed how their lack of knowledge of the patient contributed to their prescribing errors. Interviewee 21 prescribed potassium for the wrong patient after getting the patients’ blood results mixed up:

“I didn’t know them [patients] very well so I think I’d just, kind of, had just mixed up their names. There was no similarity in names or anything like that but because they were both as unfamiliar as the other I don’t think I was quite thinking at that particular time and just, you know, just put the wrong one.”

Interviewee 21 (medical school C)

Some slips reported by interviewees were influenced by poor documentation and violations made by other doctors, such as writing U instead of units:

“...it [the prescription] was quite poorly written, and then it didn’t actually say ‘units’, it just said ‘320u’ which actually looked like a zero” Interviewee 17 (medical school F)

Slips, as was expected, were often detected by the FY1 trainees themselves. This was because these types of errors were relatively easy to spot as they lay in the execution of the correct plan i.e. the doctor planned to write up IV medication but instead wrote IM. Because doctors were aware of the ‘correct plan’ they often noticed their error when checking through their prescription or by chance. On other occasions, errors were detected by nursing staff who were often present at the time the prescription was written. Another slip was detected by the pharmacist before it reached the patient and there were two slips that went undetected, both involving the wrong medication being given to the wrong patient.

Skill-based slips: Summary

Although skill-based slips were reported by several respondents, it is surprising they were not more frequent given the number of opportunities for them to occur. That is because many prescribing tasks carried out by FY1 trainees are at the skill-based level i.e. they are automatic processes requiring little conscious thought, such as in the case of rewriting drug charts or discharge prescriptions. Most probably it is this lack of conscious input that may make this type of prescribing tedious for FY1 trainees. This tedium was itself was an error producing condition.

However, the most common error producing condition associated with skill-based slips was rushing whilst prescribing. Rushing was often due to workload and other pressures. Lack of adherence to best practice by doctors other than the respondent e.g. not writing units in full and being clear in documentation was also an error producing condition for slips, which demonstrates the importance of good prescribing not just by FY1 trainees but by all doctors.

The majority of skill-based slips did not reach patients as they were detected by the various safety nets as well as by the prescribers themselves. The slips that did reach patients could probably have been avoided by a more diligent checking process.

A simplified diagram of skill-based slips is given below. This diagram depicts the overall context that these types of errors occur in and also the characteristics of the environment and prescriber which appear to predispose the FY1 trainee to these types of errors.

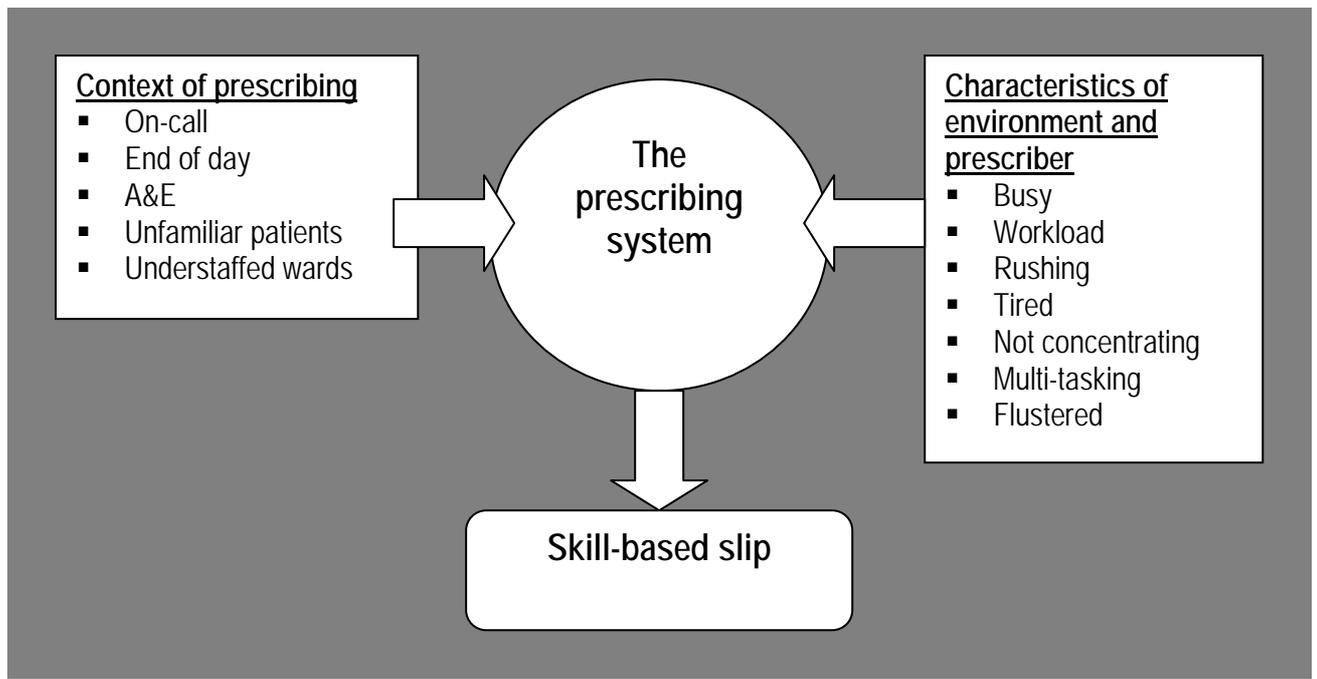


Fig 5: A simplified diagram of slips

4.3.2 Skill-based errors: Memory Lapses

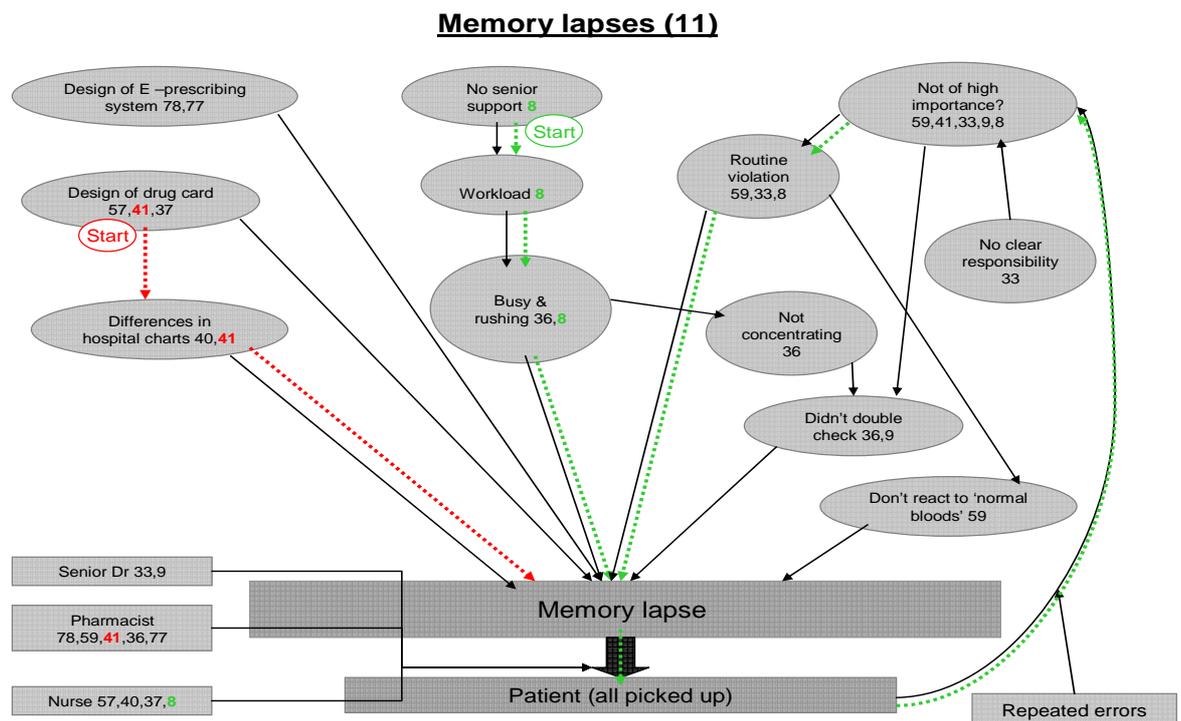


Figure 6: Factors implicated in the formation of memory lapses. The numbers in each circle relate to the number given to each critical incident. Two examples of errors are highlighted in the diagram by the red and green arrows (errors 41 and 8).

Eleven memory lapses, such as forgetting to write the time of day of a medication, were reported. These types of errors were always picked up by a nurse, pharmacist, or senior doctor. The omission of required information meant that, although treatment might have been delayed, in the majority of cases the right treatment eventually got to the right patient. Where memory lapses could have caused direct harm, such as leaving a patient on potassium for too long, these were picked up by pharmacists.

Doctors' explanations of such lapses were most often related to the design of the drug chart:

"I make errors in terms of, like, often when you re-write prescription charts you might forget to put the date and times in. On our prescription charts you get six little boxes and you're, you're re-writing the chart and transcribing it across and often you might forget to put times in the boxes...And they're all squashed together so it's very easy to miss..." Interviewee 19 (medical school A)

Doctors' experiences of working as medical students in other hospitals, which had different drug chart formats, influenced their ability to correctly complete the chart:

"...previous prescription charts and places when I was a student, you didn't have to write the time, you circled them. So I, it's, it's a different thought process, having to put the times of day you want it...and it's been more just getting used to that I think." Interviewee 15 (medical school E)

One doctor discussed how he had, on several occasions, missed patients' medications off their discharge prescriptions. His explanation for these errors was the poor design of the electronic prescribing system which he described as "cumbersome". He went on to explain how these errors arose:

"...the screens as you're prescribing stuff will only accept a certain amount of drugs per screen...so if somebody is on twenty medications for example and your doing the take home drugs, once you put so many in, it forces you to

review them and enter them on the system and you have to go back in again and prescribe the ones you've missed off... so just because the way the computer system works, it's very easy to miss medications off...." Interviewee 27 (medical school A)

His forgetting of patient's medications was strongly associated with the design of the electronic prescribing system, an interesting latent condition because a high number of errors were reported from that one hospital in the prevalence study.

Forgetting to put a stop date on IV infusions and forgetting to write prescriptions for controlled drugs in the required manner were two memory lapses reported by interviewees and attributed to being busy. This foundation trainee who forgot to write up controlled drugs in the correct manner described how such errors like this were caused by being busy:

"There's been many occasions like I'd be on the phone trying to sort something out and writing a TTO at the same time, and you really shouldn't do that. Do you know what I mean, but you have to sometimes because you haven't got enough hours in the day to do everything." Interviewee 13 (medical school H)

These errors were most likely to be repeated by doctors who were either "hardwired" to work with certain prescription charts or perhaps became reliant on safety mechanisms, such as nurses or pharmacists, to correct errors.

Memory lapses also contributed to errors of which they were not the primary cause as discussed in the next section.

Memory lapses: Summary

A lack of support and being busy were error-producing conditions for memory lapses as for other types of error but drug chart design was a condition uniquely associated with memory lapses.

As all lapses were in fact picked up, it is clear that safety mechanisms were operating successfully. However, the time taken to rectify any lapses may have caused an unnecessary burden on other healthcare professionals such as nursing staff. A feeling that these types of errors were not overly important, perhaps due to the effectiveness of safety nets such as pharmacists and nurses, was also an error producing condition.

Figure 7 depicts the context and environmental characteristics for memory lapses.

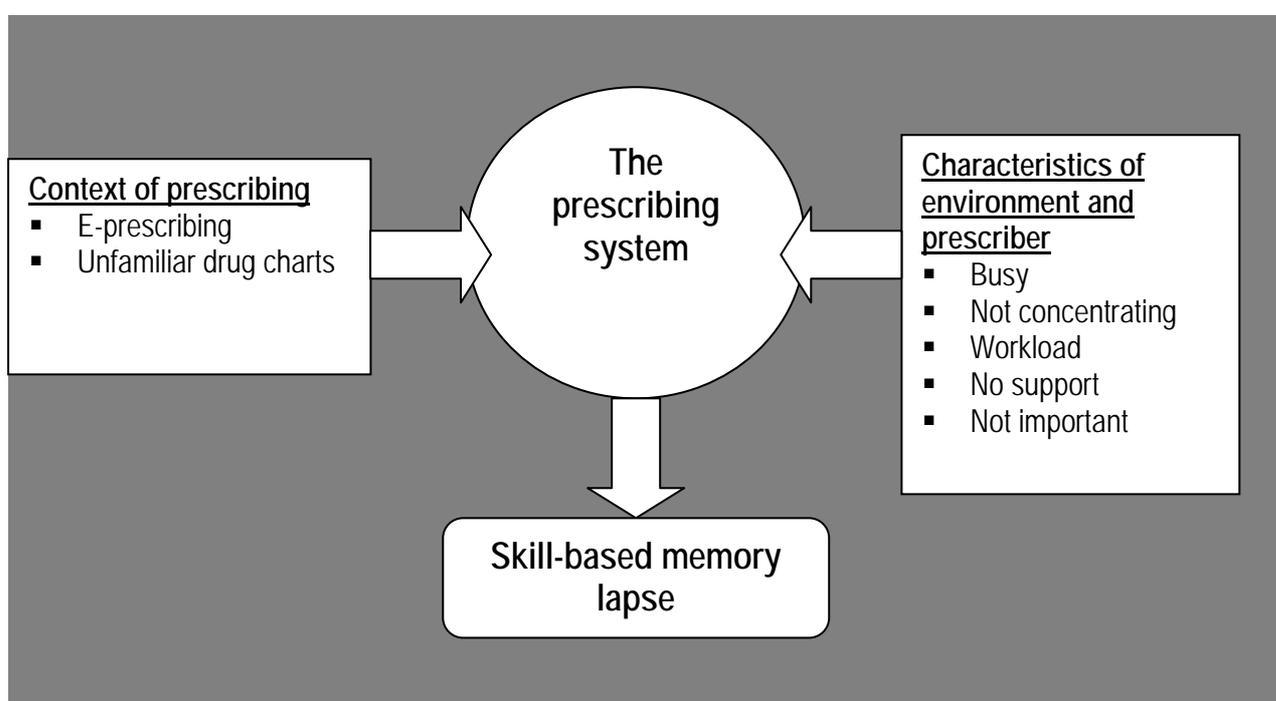


Fig 7: A simplified diagram of memory lapses

4.3.3 Rule-based mistakes (RBMs)

RBMs were the most common active failure, with 34 incidents of this nature being recalled by interviewees as depicted in figure 8. RBMs are different to skill-based slips and memory lapses in that the activity being undertaken is a problem solving activity (e.g. deciding what to prescribe for a patient requiring analgesia) rather than a routine task (e.g. rewriting a drug chart). Decisions are made by drawing on a set of rules that have been applied in previous

scenarios. Mistakes occur when rules are inappropriate to the current scenario or the right rule is not applied (see methods section 4.2.1).

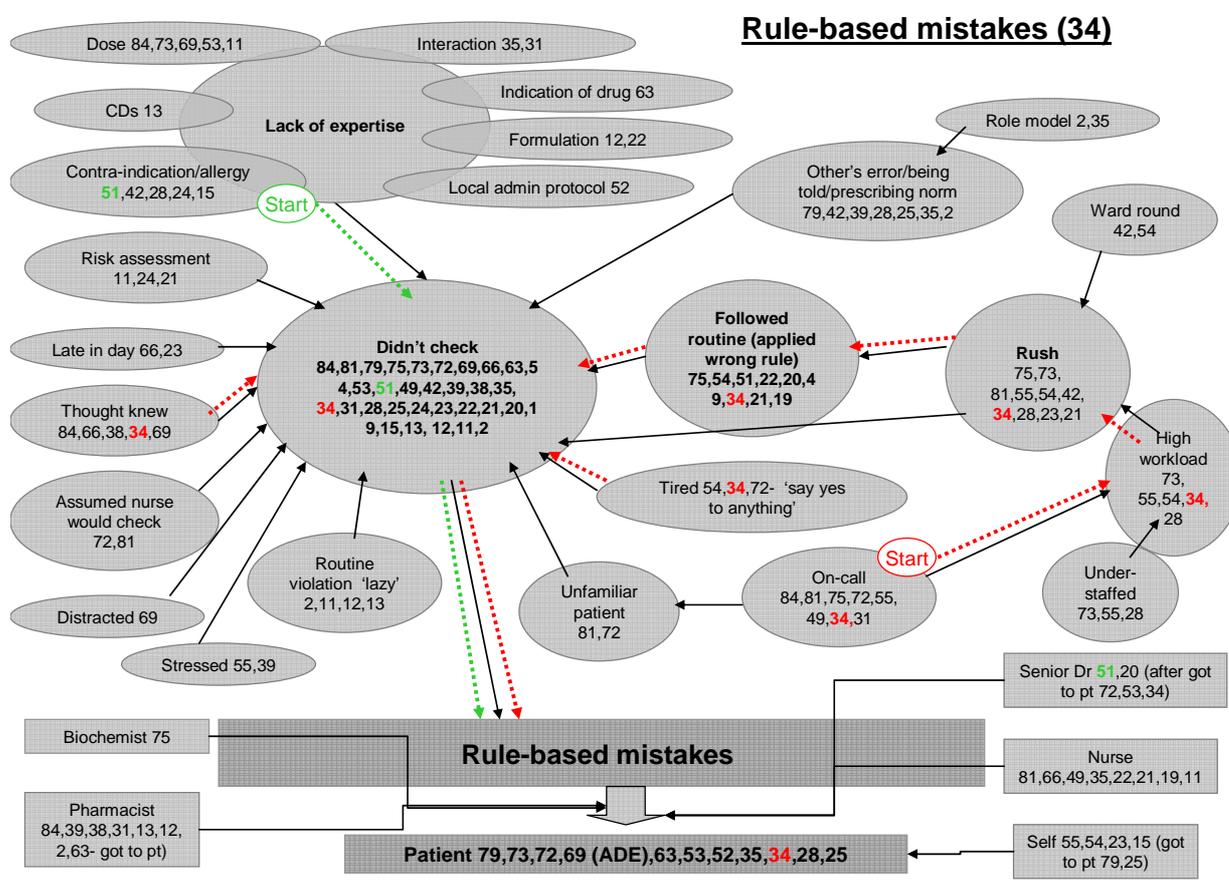


Figure 8: Factors implicated in the formation of RBMs. The numbers in each circle relate to the number given to each critical incident. Two examples of errors are highlighted in the diagram by the red and green arrows (errors 51 and 34).

Trainees' lack of expertise was an important cause of RBMs. Because they lacked expertise in framing the clinical situation they applied the wrong rules. At other times they selected a rule that they had applied previously, many times, but which, in the current circumstances (e.g. patient condition or current treatment), was incorrect. Interviewee 26, for example, prescribed normal saline to a dehydrated patient who had a high sodium level as this was what she normally prescribed:

“...when we’re on call we tend to get asked to prescribe fluids all the time every ward we go onto somebody will say, you know, “This person needs fluids” and so you...I tend to prescribe you know normal saline followed by another normal saline with some potassium in and I tend to have the same sort of routine that I just follow...” Interviewee 26 (medical school R)

Some doctors, in hindsight, reported a lack of expertise in dosing, drug-drug interactions, formulations, contra-indications, controlled drug regulations and drug indications. Yet at the time of the error, doctors were unaware of their ignorance.

At other times, doctors applied a wrong rule despite knowing the correct one as they had misjudged a situation. These types of errors occurred frequently and were the cause of a lot of frustration for doctors. This FY1 trainee prescribed ibuprofen for a patient who was taking anticoagulants in whom the prescription was contraindicated:

“But it’s just so obvious. Like, I knew that, I knew that, like, they interact, it’s just really annoying.” Interviewee 9 (medical school b)

Doctors discussed how they used ‘automatic thinking’ and would make an error despite having learned relevant knowledge at medical school:

“And I learnt it at medical school, but just when they start ‘can you write up the normal painkiller for somebody’s patient?’, you just don’t think about it. You’re just like, ‘oh yeah, paracetamol, ibuprofen’, give it them, which is a bad pattern to get into, sort of automatic thinking.” Interviewee 7 (medical school c)

The most common feature of these types of mistakes was the doctor’s failure to check their prescription with another member of staff or with a reference

source. The reasons for not checking varied but commonly doctors felt 'they thought they knew' what they were doing:

"Q: Do you think anything could've prevented that error?"

A: Well, if I'd of looked up the dose, but, erm but I thought it was one that I knew so. What would've prevented it is if I'd of been unsure of, of the, sort of, frequency then I'd of looked it up and then..." Interviewee 14 (medical school K).

"It wasn't the type of thing that you would think that you'd need to ask someone senior about whether I should prescribe, do you know what I mean?" Interviewee 13 (medical school h)

Others reasons included assuming that a nurse would flag up any potential problems such as a contra-indication, possible interaction or duplication. This FY1 trainee was asked to prescribe fluids for a patient and did not realise the patient had already been prescribed a potassium supplement. He subsequently prescribed fluids that contained further potassium:

"I just didn't open the chart up to check, I sort of just assumed if the patient...if they're [the nurses] asking me to prescribe fluids to someone with low potassium, I wrongly assumed the staff would point out if they're already on potassium replacement therapy." Interviewee 28 (medical school N)

Being in a rush was a common error producing condition for RBMs. As with other types of errors, workload and staffing issues were mentioned as reasons for doctor's rushing. Being on-call was also associated with RBMs. This interviewee was discussing a RBM that he had made whilst on call. Part of his explanation for the error was that he would say yes to anything when he was tired:

"A: ...when the nurses call you, "can I just give this chap fluids?", "like just prescribe this and this and this"..."

Q: *Okay.*

A: *So then I said “yeah just prescribe this first and I’ll sign for it later”, and I didn’t ask for any medical history or anything like that...so over the phone at three or four o’clock you just say yes to anything.”* Interviewee 25 (medical school T)

Other RBMs occurred because doctors did not look up dosages because they were in rush but also because they felt the risk was small enough to take. Interviewee 4 violated the expected rules of prescribing by not checking a dosage because she thought there would be little difference between different proton pump inhibitors (PPI):

“...it’s only a PPI and I didn’t think there’d be that much difference between them, but clearly there is.” Interviewee 4 (medical school N)

RBM’s frequently reached the patient and one resulted in a serious adverse drug event. Others were averted by hospital safety mechanisms, principally the vigilance of pharmacists, nurses or senior doctors, though sometimes too late in the latter case.

Some RBMs resulted from senior doctors making mistakes or violations which the FY1 trainee merely continued. This applied both to individual prescribing decisions and the application of rules.

There were a few incidents in which FY1 trainees were ‘following orders’ given to them by senior doctors, which did not take account of a patient’s allergies. FY1 trainees in this situation failed to check the patient’s allergies and subsequently prescribed medications which were contraindicated. These types of incidents were rated as potentially lethal, although most of them were detected before they reached the patient. Neither of the two errors that reached a patient caused harm and it is probable the patients did not have a true allergy. However, prescribing medication to a patient with an allergy was a very common type of error. They seemed to result from two active failures; a

memory lapse i.e. forgetting to check the allergy box, which then led doctors to select the wrong rule, resulting in a RBM. The interviewee below was glad she noticed the patient's allergies before the antibiotics she had prescribed were administered:

"I had clerked her in and then, obviously, you go and you do some other things then I came back and just looked at the x-ray and the bloods and went to prescribe her benzylpenicillin and levofloxacin and literally... Er, so I prescribed them and the nurse got them up and was literally linking them up when it just dawned on me that she was penicillin allergic, but it was a complete fluke that it had dawned on me before they were given, but that, you know, the nurse hadn't double checked it. I hadn't, I hadn't double checked it when I prescribed it, erm, despite having her prescription chart I just, I think I was just busy and I just didn't think to cross reference and, you know, be systematic about thinking of allergies every time you write down, er, an antibiotic." Interviewee 19 (medical school A)

Rule-based mistakes: Summary

Unlike KBMs, FY1 trainees who made RBMs often had the knowledge they required to prescribe a medication correctly. Their errors occurred because of a lack of expertise when applying their knowledge, which resulted in foundation trainees applying the wrong rule in the present situation without checking the prescribing scenario was similar. Some trainees appeared to lack expertise in dosage, formulation, controlled drugs, interactions and contraindications. However, unlike KBMs, doctors were unaware of their ignorance and often proceeded to write a prescription without checking its appropriateness. In fact many of these RBMs could have been prevented if the prescription had been checked or double checked for allergies, interactions, and contraindications. Interviewees had sometimes experienced a memory lapse and forgotten to check these details because they were busy. In other cases, checking was not part of their normal routine when prescribing. Assuming that nurses would provide information without prompting was also a cause of mistakes.

RBM s were the most likely to evade defence mechanisms; the prescribers themselves were often unaware of their mistakes, prescribing medications they were familiar with but in the wrong circumstances. The prescribing decisions themselves were not particularly outlandish and would be correct in the right circumstances, so they went unnoticed by others. The fact that several of these mistakes occurred whilst on-call may have made them even more difficult to capture as surveillance by pharmacists was least available at that time.

Figure 9 depicts a simplified version of RBMs.

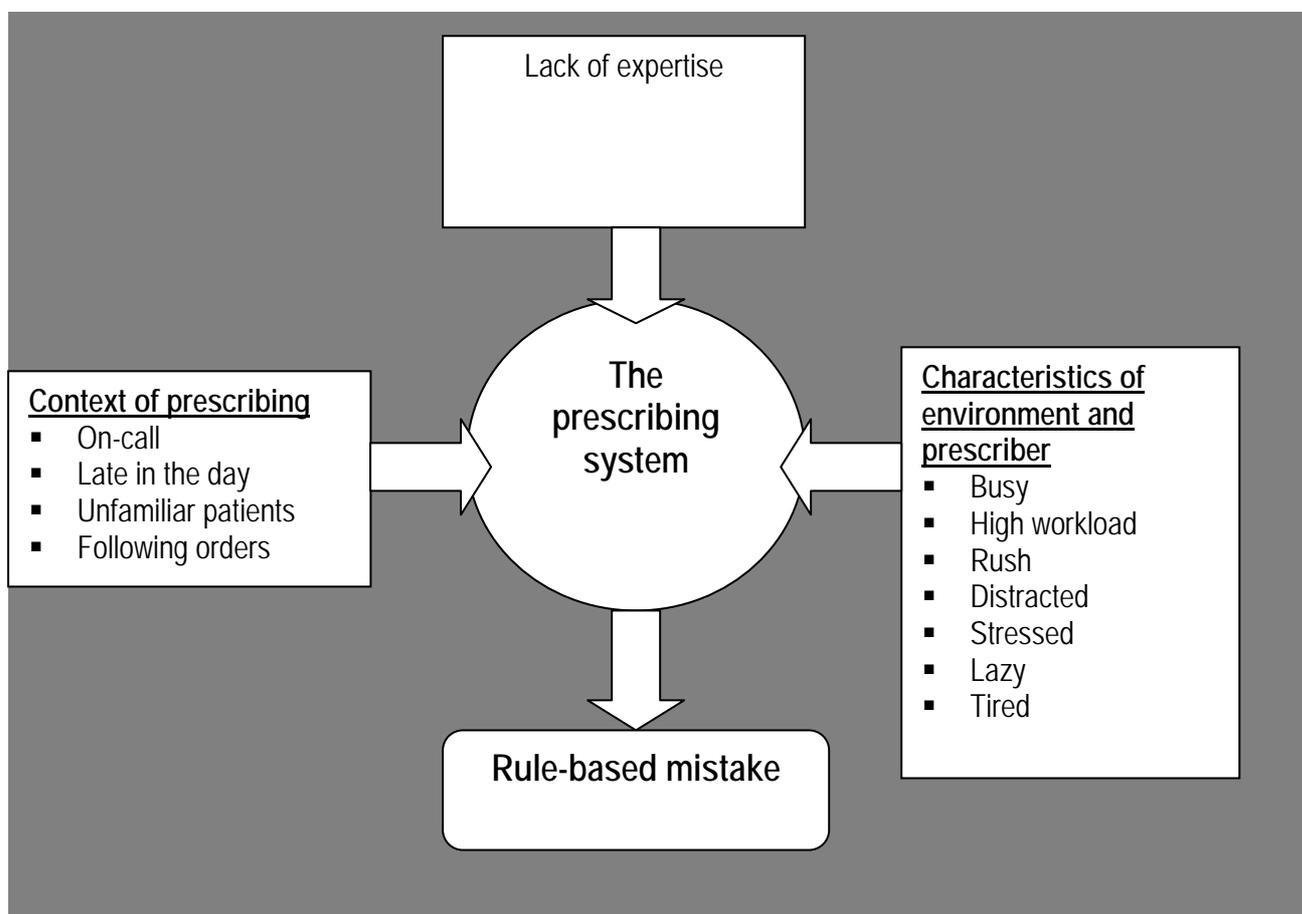


Fig 9: A simplified diagram of RBMs

4.3.4 Knowledge based mistakes

Eighteen KBMs were reported by interviewees. Figure 10 depicts the error producing conditions and latent conditions leading up to the formation of KBMs.

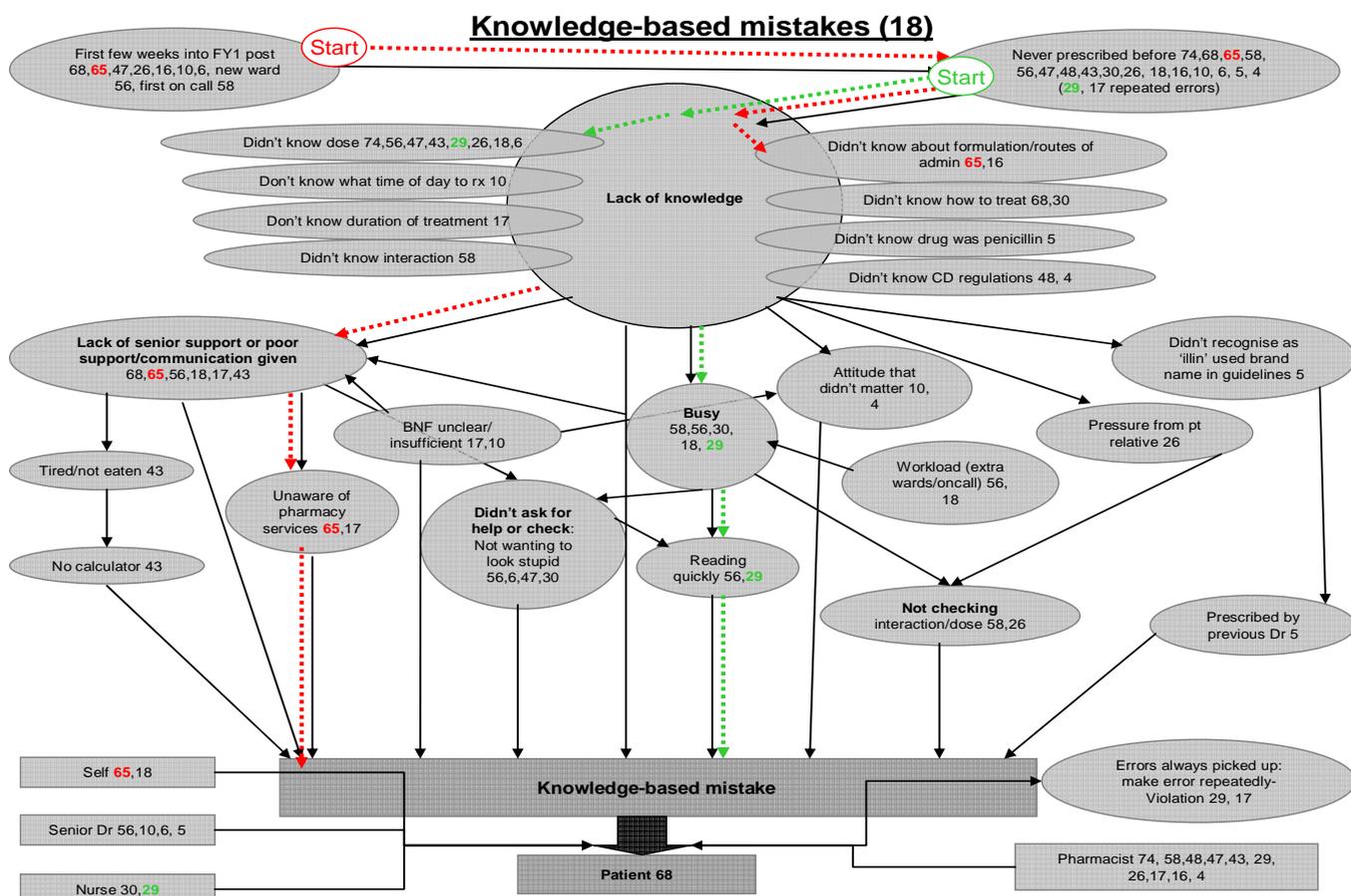


Figure 10: Factors implicated in the formation of KBMs. The numbers in each circle relate to the number given to each critical incident. Two examples of errors are highlighted in the diagram by the red and green arrows (errors 65 and 29).

KBMs were all associated with prescribing medications which were novel to the FY1 trainee, as described in the methods section (4.2.1). Therefore, they often occurred during the first few weeks of starting as an FY1 trainee, or during the first couple of weeks of starting a new post within a rotation.

A lack of knowledge was a common factor in these mistakes; however, the type of knowledge that was lacking varied amongst interviewees. A deficit of knowledge regarding the dosage of medication was most frequently reported:

“Q: Can you think of any other errors that you’ve made?”

A: Erm, things like, er, dosing up carbocystine, well I look in the BNF and I just get confused about how I’m meant to start off prescribing it, I think you’re meant to prescribe it at certain days to begin with and then change it as you go along. So I get confused with things like that.” Interviewee 11 (medical school L)

Two doctors were unaware of the controlled drug regulations, leading them to write prescriptions that were illegal:

“A: I did a take-home prescription for some morphine, and I didn’t write numbers and words...and I didn’t specify how many vials to be given, erm, so the, the prescription got sent back up by pharmacy and it had to be done again.”

Q: Okay. And why do you think you made the error?

A: Erm, I’d just never been taught how to do it” Interviewee 18 (medical school G)

Another two doctors made mistakes in the formulation or route of administration of a medication. This doctor prescribed pamidronate incorrectly but then spotted his error later on that day:

“...because I hadn’t really...given many infusions at that point, erm, that, you know, I was just, I was convinced that was the, just an IV drug to be given that route. Erm, but then I checked the BNF and I checked the infusion book and it was an infusion, so I changed it. I stopped it.” Interviewee 22 (medical school O)

Two doctors lacked knowledge of the treatment of pain. One of these incidents involved the prescribing modified release analgesia without the analgesia for break through pain:

“the last one [error] was prescribing OxyContin and OxyNorm, I think, one of them is, I still don’t actually understand this, one of them is, erm, to be given as a slow release so it’ll be used twice a day, and the other one’s PRN, so is as required, and it has more rapid effect, erm. And I really didn’t understand how to prescribe that and I’d prescribed it wrong...I think I’d prescribed the, just the, the one that you give twice a day, but not anything on the PRN side for as required.” Interviewee 11 (medical school L)

The treatment of pain was an area in which doctors would have liked more training. Furthermore, a lack of knowledge of the different dosage formulations was reported in several interviews. Other areas where respondents lacked knowledge included the timing of dosage, the duration of antibiotic treatment and drug-drug interactions.

However, with the exception of two, all KBMs were affected by factors other than an outright lack of knowledge; respondents were aware of their knowledge deficit at the time of the prescribing decision and either approached others for assistance or chose not to seek help and went ahead with the prescription.

Those that requested advice or sought help from others usually approached someone more senior within their team. However, problems at this step arose when the senior did not communicate effectively, failed to provide essential information, or was hurried. Two errors were caused by being instructed how to prescribe over the phone by another busy doctor. Furthermore, both of the errors occurred whilst the doctor was working on-call and therefore unfamiliar with the patient:

“...it was basically the fact that I didn’t know how to do it, you know, you’re bleeped to a ward, you’re asked to do it and you don’t know how to do it, so

you bleep someone to ask them and they're stressed out and busy as well, so they're trying to tell you over the phone, they've got no knowledge of the patient, you've barely got any knowledge of the patient ..." Interviewee 6 (medical school J)

Occasionally, the information given by a senior doctor was incorrect, a type of error that is discussed under the heading communication (section 4.3.5).

The doctor, mentioned previously, who was uncertain about how to prescribe pamidronate was instructed to prescribe by a registrar. However, when the registrar gave him advice, he provided only limited information about how to prescribe the medication:

"I got in touch with the endocrine, erm, team, to say, you know, "What shall we do about this lady?" ...And, erm, the endocrine reg came down, erm, saw the patient, erm, and said, "Oh, yeah, give her some IV pamidronate...But I didn't realise it was an infusion. I thought it was a stat dose drug cos of the way he'd written it. He hadn't written it IV pamidronate infusion and, erm, I hadn't checked it." Interviewee 22 (medical school O)

On some occasions, the FY1 trainee was alone without anyone in their team to contact for advice:

"This was in my first couple of weeks of working, yeah, it was probably September, the end of August actually. And then I was on my own and there was no SHO, and there was no registrar at the time..." Interviewee 29 (medical school C)

Some doctors discussed how they were, at the time of the incident, unaware of the pharmacy services offered by their hospital. One doctor who found himself without any support felt that had they had known about the pharmacy information service they may have been able to get the correct information that they required:

“...there was a number, I found it later, but it wasn't, I, I wasn't ever aware there was like, a pharmacy helpline or, or our drug helpline you could ring, cos as I said, like, pretty busy, like, apart from that induction week, you know, I didn't really know any other, of the other F1s. You know, most of them are [medical school A] trained, erm, and... So I wasn't aware of things like this that were in the hospital.” Interviewee 22 (medical school O)

In three incidents, doctors consulted the BNF to gain information yet the information they sought was either absent or unclear:

“...sometimes on the ward round the consultant has said, “Right, this person can go home and have Augmentin” and then they've gone to the next patient, but when I'm writing on the ward round, “Okay, I have to do TTO for this later.” So I've written Augmentin, the dose, whatever times a day, but I have never asked the consultant for how many days...And sometimes it doesn't say in the BNF.” Interviewee 5 (medical school M)

Another incident occurred in which an FY1 trainee was uncertain about how to prescribe amphotericin and, although she consulted a senior doctor over the phone about how to prescribe it, she subsequently made an error in placing the decimal point. One reason for her error was because she did not have a calculator available as well as feeling tired and hungry at the time:

“I mean it must have been a) a simple maths error, b) I didn't have a calculator, and c) I think it was about half 8 in the evening, and I hadn't had lunch or, er, eaten anything, like, all day. So I was like, I was about to go crazy.” Interviewee 16 (medical school D)

Not all of the doctors who reported KBMs approached others for advice, and in almost half of knowledge-based incidents doctors consciously did not seek out information such as dosage or drug-drug interactions. Doctors often attributed the decision not to check a prescribing decision to their busyness. This busyness was due to reasons such as covering more than one ward, feeling under pressure by a patient's relative or working on call, a theme that was consistent in all types of error.

One FY1 trainee recounted an error that she had made in the dosage of metformin. One explanation for her mistake was the pressure she was under from the patient's relative:

"I was in a bit of a rush as well, because she was waiting for her, erm, medications, cos they had to be sent down to pharmacy and then come back and her husband/partner was, like, going mental on the ward, cos he was drunk. And, er, so, er, I think I was just trying to be as quick as possible."

Interviewee 9 (medical school B)

Being busy also led one doctor to read information about a medication quickly so that she misinterpreted the dosage and prescribed the incorrect amount:

"I checked the BNF but then afterwards wrote up the regular dose but prescribed it [digoxin] at too high a level for a starting dose. I think I, I looked, I glanced at the dose but I didn't prescribe it, like, didn't do it carefully because I was trying to do another ward round..." Interviewee 19 (medical school A)

Busyness was not always a factor in doctors' decisions not to check a particular prescription. In some cases doctors chose not to seek advice or information because of the way that this might be perceived by others in the medical and nursing team. One interviewee felt that more senior doctors might judge him if he had to look up information about prescribing:

"I knew I should've looked it up cos I didn't really know it, but I, I think I just convinced myself I knew I because I felt it was something that I should've known....because it is very easy to get caught up in, in being, you know, 'Oh I'm a Doctor now, I know stuff,' and with the pressure of people who are maybe, sort of, a little bit more senior than you thinking 'what's wrong with him...you don't wanna always be seen to be in, you know, 'what's the dose of paracetamol?'" Interviewee 2 (medical school H)

Another doctor discussed how he had chosen not to check a prescribing decision with his senior as it was his first day on a new ward:

“...I didn't discuss that one... I think it was probably because it was a new job and you're tame... I mean, you don't want to look stupid on the first day... You don't know what they expect of you. They're, kind of, all rushing round so you're trying to keep up, erm, and you just, kind of, you're, you're trying to keep up with them and you, you don't want to, you, you don't know them well enough to feel comfortable asking them questions that they might, that you don't know they might think that's a stupid question so you, kind of, try and do a bit more yourself. Whereas on my, like, on my old ward I know I probably would've said to my Reg, “Oh, what's the dose?”” Interviewee 19 (medical school A)

FY1 trainees discussed how they eventually learned that it was in fact acceptable to check information. One doctor discussed how he liked it when consultants would look up doses, portraying the acceptability of such actions:

“... I find it quite nice when Consultants open the BNF up in the ward rounds. And you think, well I'm not supposed to know every single medication there is, or the dose.” Interviewee 16 (medical school D)

The decision not to check prescribing decisions was also influenced by more latent conditions. One mistake made by a doctor was the prescribing of Timentin to a penicillin allergic patient. The fact that the name did not end in 'illin' meant the prescriber did not recognise that this antibiotic contained penicillin. The error was also affected by the antibiotic having been prescribed to the same patient by another doctor before:

“...the antibiotic guidelines for this hospital, it just comes up as Timentin, which is it's trade name. I think it's Ticaracillin its actual real name is. So if, if you say it like that, it's obvious it's penicillin, but, erm, but if you just say Timentin, it's just this magic thing that you write down on, on, on the, er, on the drug card... so it just didn't click into my head that I should be checking whether they, erm, whether they're allergic to it or not.” Interviewee 2 (medical school H)

The majority of KBMs were detected by pharmacists prior to reaching patients. Senior doctors, nurses and doctors themselves also detected the mistakes before they reached patients and only one actually resulted in a patient not receiving appropriate treatment. In this particular case, a doctor was left without support in a particularly difficult clinical situation:

Sometimes errors were made on more than one occasion, with doctors never resolving their lack of knowledge. This behaviour only occurred when doctors believed their errors would be corrected further down the line of the prescription process.

“Sometimes if I don't know and I can't get hold of anyone and I can't get the BNF, I don't even write it. I don't write for how many days, cos I know pharmacy will ring back. I've done that before.” Interviewee 5 (medical school M)

Knowledge-based mistakes: Summary

Knowledge-based mistakes had their origins in doctors' lack of prescribing knowledge, particularly dosage. These doctors would not be expected to know the dosages of all the drugs they prescribed but they would be expected to obtain the correct information. Doctors also lacked knowledge of interactions, duration of treatment and routes of administration amongst other things, all of which are practical aspects of the prescribing process and most of which could be rectified by seeking information from pharmacists and other reference sources.

However, occasionally deficits in the support mechanisms led to errors. Foundation trainees received poor information, communicated ineffectively and were sometimes unaware of where and how to seek assistance.

Image was important to some FY1 trainees who chose to keep quiet about their lack of knowledge to avoid looking stupid. This behaviour subsided as doctors became more familiar with team members, becoming more comfortable asking for help. Doctors realised their own high expectations

when observing senior doctors who checked information, which made them recognize that this behaviour was acceptable. This finding was strongly related to the professional culture of medicine and is discussed under a separate heading (see section 4.4.3).

Busyness was a factor in all pathways of KBMs, regardless of whether information was sought or not.

It was possible from the analysis to produce a simplified diagram depicting the KBMs that were captured by this study shown in figure 11.

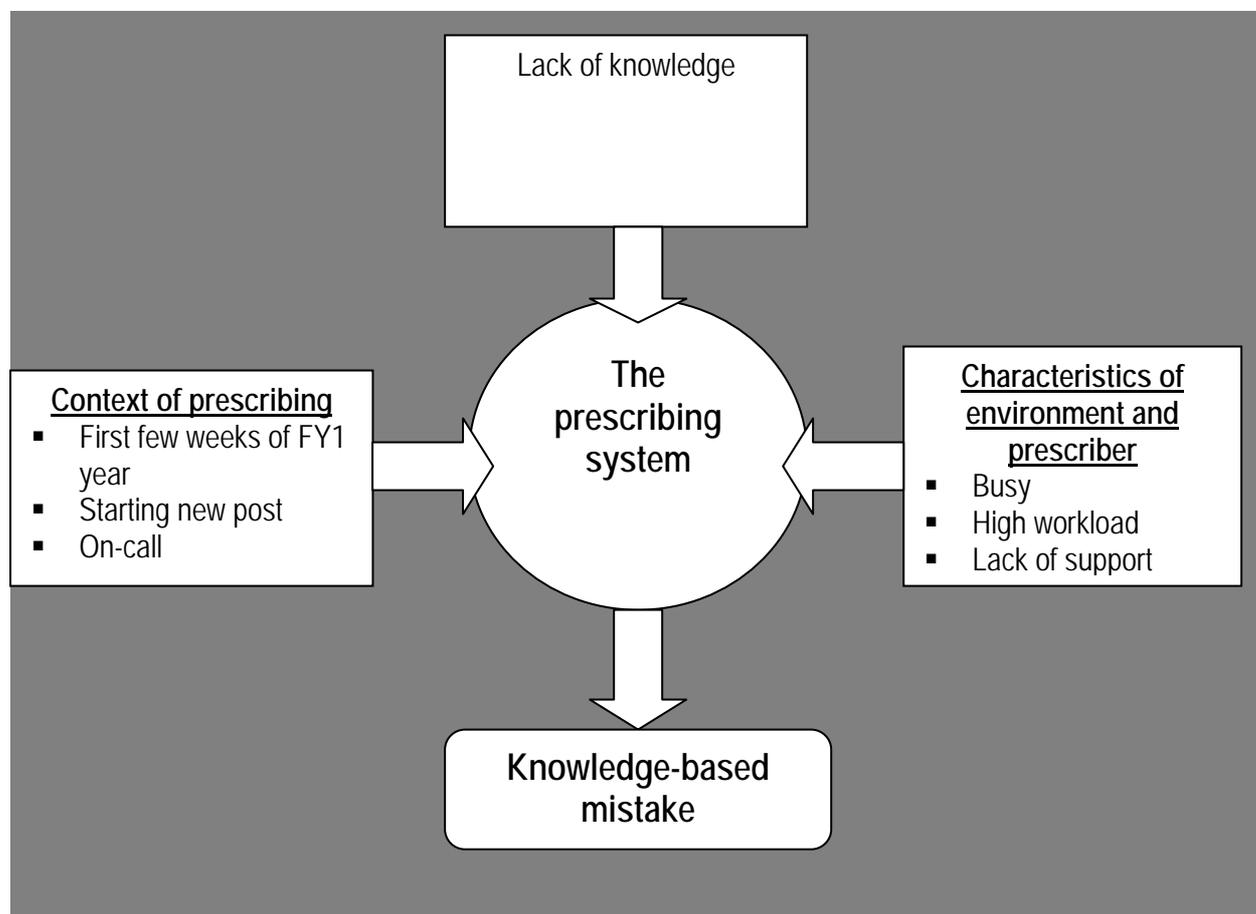


Figure 11: A simplified diagram of KBMs

4.3.5 Communication errors

Not all errors that doctors reported could be categorised according to Reason's model. This was because the FY1 trainee was not always the source of an active failure. Such errors arose when FY1 trainees received erroneous information from either patients or other healthcare professionals, who were thus primarily responsible for the active failure of some kind. However, as the FY1 was the doctor writing the prescription, they bore legal responsibility for it.

Figure 12 below includes all of these incidents and the factors related to their occurrence.

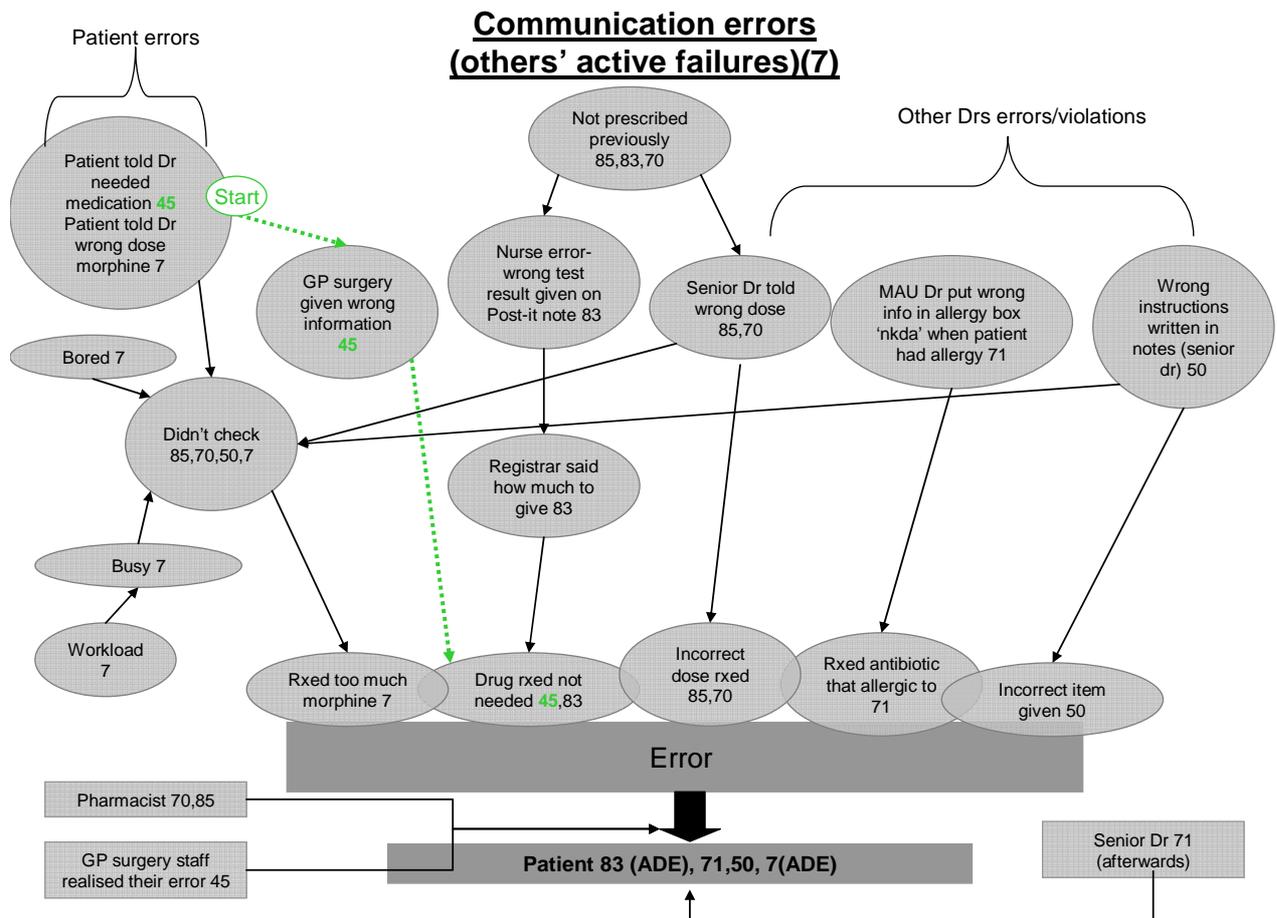


Figure 12: Factors implicated in communication errors

Incorrect information from patients was sometimes the source of errors of this type. One incident involved a prescription for morphine in which the patient told the doctor that he took a higher dose than he actually took:

“...they [the patient] rattled off their drugs probably better than anyone I've ever met, you know, most people are like, “I take a yellow pill on a Thursday and...” but this person, you know, they were, “I take a omeprazole 40 milligrams once a morning,” this and this and this. Erm, and then the Morphine dose that they told me was, was wrong, erm, it was... I can't remember the exact figures, but it was, it was, you know, substantially wrong...we never really got to the bottom of it, whether it was, er, an honest mistake on the patient's behalf or whether it was a, sort of, drug seeking thing. Erm, but at the end of the day it's me who, who, sort of, wrote it down and gave it to them without, sort of, erm, much questioning, but it did mean that they were seriously relaxed that afternoon.” Interviewee 2 (medical school H)

On another occasion, a patient requested his Zoladex injection despite having only received it the previous day. This was checked with the GP surgery, which incorrectly confirmed the patient's request. Fortunately a GP spotted the error later that day, prior to the patient receiving the medication:

“...whoever she [the pharmacist] spoke to at the GP's had misconstrued, had basically got confused. Cos he was also on, erm, injections for B12, you know, for low iron. And I think she got confused as to what injections the pharmacist was talking about, and had, and hadn't checked with his regular GP, and had just said, “Oh, he had an injection on so-and-so a day.”

Interviewee 17 (medical school F)

In half of all communication errors, it was a senior doctor's error that was the root cause of an FY1 trainee's prescribing error. Two incidents were caused by senior doctors informing an FY1 trainee of the wrong dose to prescribe. Interviewee 29 prescribed the wrong dose of metronidazole but when checking the dose with a senior he received the incorrect information:

“...I asked a senior I said “is it the same as 500?” and he said, “yes”.”

Interviewee 29 (medical school C)

Another error occurred when an FY1 trainee prescribed penicillin to a patient who was allergic because the allergy box said NKDA on a previous drug chart:

“I actually rewrote the drug card on a previous drug card which came up from MAU, it said no known drug allergies. So I just like re-prescribed it as no known drug allergies.” Interviewee 25 (medical school T)

Nurses were also involved in one error, whereby the wrong test results were put with a patient’s drug chart:

“The nurse came up to us and said “Oh there was a post-it note on front of the drug card with her HB is 7.8” or something, so the reg just went, “Yeah fair enough give her three units” so I prescribed her three units of blood, thought nothing of it. A couple of days later, I thought I’d check what her post transfusion haemoglobin is, she’d only had two units so far and I was looking through it and I couldn’t find anywhere on the system this 7.8 and it was only when I sort of looked really detailed I found that on that day her white cell count was 7.8 and her haemoglobin was actually like 12 or something, so we’d transfused her up to sort of 14...I always check every single INR, blood everything nurses say I always go and check it myself on another computer.”

Interviewee 28 (medical school N)

As interviewee 28 discussed above, these types of errors made doctors mistrust information given to them by other members of staff and also patients. This made more work for FY1 trainees who felt it necessary to double check information given to them by other members of the healthcare team.

Half these errors reached the patient, the remainder being detected by a pharmacist or, in one instance a GP.

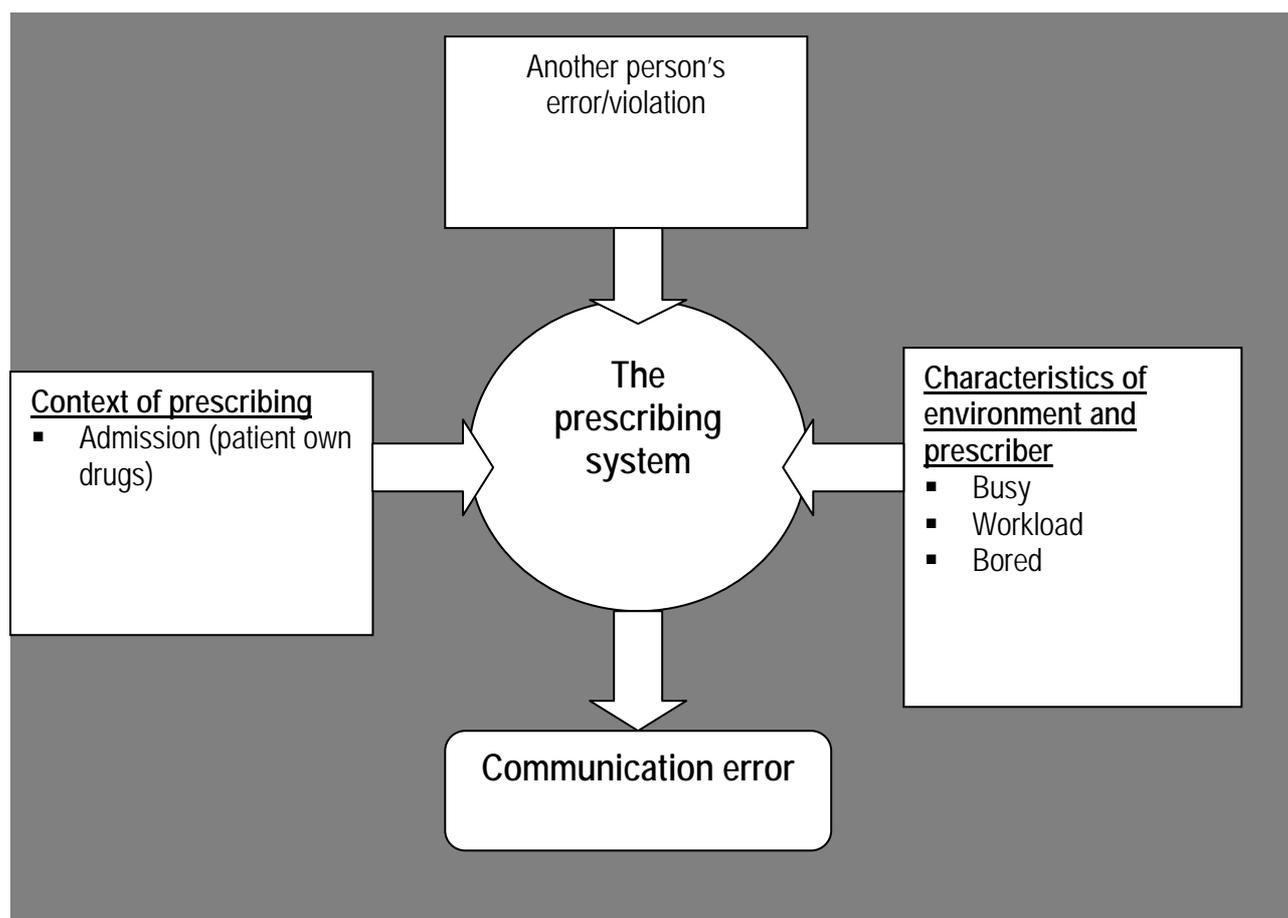


Fig 13: A simplified diagram of communication errors

Communication errors: Summary

Communication errors were not an active failure of the FY1 trainee, yet it was the junior doctor who bore responsibility for the prescription they signed. As it was not possible to interview others who were associated with these errors, it is very difficult to come to any firm conclusions about their origins and any possible interventions. However, their presence in the study highlights the way in which errors can be perpetuated in the healthcare setting. It also demonstrates how prescribing errors, despite appearing at first glance to be due to the erroneous actions of an FY1 trainee, can be due to active failures of others.

4.3.6 Violations

Violations played a part in several FY1 trainee prescribing errors. Occasionally the active failure was a direct violation when writing a prescription but more commonly violations were error-producing conditions that led to other active failures. An example of the former was when a doctor intentionally decided to omit required information on a prescription. The latter might be a scenario in which a doctor knowingly ignored computer alerts which in itself would not necessarily result in an active failure but could, in certain circumstances, result in an error.

Situational violations, the most common type of violation, occurred when doctors made a conscious decision to violate rules in order to 'get the job done'. One example of this was given by a FY1 trainee who did not know the dose of nystatin liquid as he did not have access to a copy of the BNF, yet he prescribed it as nursing staff required the item quickly. The decision to prescribe without checking was made as he believed there was little difference between the dosages and no harm was likely to result. In the meantime, he could find out the dose and alter the prescription later:

"I don't think I had a BNF available at that time, erm, and the nurse needed to get it sent down to pharmacy so the nystatin could be sent up, erm, so my thoughts were that the difference between TDS and QDS it's not a huge difference, it's not going to make, erm, that much difference if I change it, if I checked BNF now and delay getting the, er, nystatin or whether I check it later on so just to get it sent away I put it as sort of TDS." Interviewee 23 (medical school Q)

There were several scenarios in which FY1 trainees felt forced to violate a rule because of situational factors. Not checking information that should routinely be checked, such as allergy status or dosage, was often attributed to a lack of time. Being rushed and busy were two of the most common error-producing conditions found in the study and were often related to a shortage of staff and high workload.

Other violations were routine type; for example, one FY1 trainee repeatedly wrote controlled drug prescriptions incorrectly because he saw it as a minor error that would be corrected by pharmacy. Other examples included doctors omitting specific information on a prescription. Such violations rarely affected patients as various safety nets detected and corrected them. Another example of a routine violation was given by an FY1 trainee who did not normally check patients' second drug chart. However, this routine violation resulted in the patient being prescribed two doses of antibiotics:

"I think that is something I wouldn't normally do [check the second drug chart]. Erm, cos you, I don't think I've ever seen a case where that, erm, a double, er, er, a drug, certainly an antibiotic's been written up twice and, erm, it's the kind of thing that you just think will be picked up by somebody else...." Interviewee 12 (medical school E)

As these examples show, doctors did not expect their routine violations to result in errors.

Violations: Summary

Active failures that were direct violations were rare; however, situational violations and routine violations contributed to other active failures and could therefore be regarded as error-producing conditions. Many violations happened when an FY1 trainee was trying to 'get the job done' under pressure.

4.3.7 Conclusion

FY1 trainees' prescribing errors resulted from a variety of active failures. By analysing our data in this way it is possible to see how active failures, error producing conditions, and latent conditions interconnect to result in a prescribing error. The different pathways that these active failures follow make it likely that different types of interventions will be required at different points in the error pathway dependent on the active failure. One important finding of this study is that errors are often the result of more than one active failure, various errors provoking conditions, and various latent conditions.

Table 8 sets out the various characteristics of the environment and the prescriber that was associated with prescribing errors. From this it is clear to see that there were several common themes for all types of errors, most notably busyness, workload and a lack of staff.

Table 8: Characteristics of the environment and prescriber associated with each type of error

	Slips	Lapses	Rule-based Mistakes	Knowledge-based mistakes
Characteristics of the working environment	←———— Busy —————→			
	←———— High workload —————→			
	←———— Lack of support/staff —————→			
Characteristics of the FY1 trainee	Rushing		Rushing	
	←———— Not concentrating —————→		Distracted	
	Flustered		Tired	
	Multi-tasking		Stressed	

The context of these errors was, however, a little different for each type and these are given in table 9 below

Table 9: Context of prescribing associated with each type of error

Slips	Lapses	Rule-based Mistakes	Knowledge-based mistakes
On-call	Electronic prescribing	On-call	On-call
End of the day	Unfamiliar drug charts	Late in the day	First few weeks of FY1 year
Unfamiliar patients		Following orders	Starting new post
Understaffed wards		Unfamiliar patients	
		Understaffed wards	

From table 9, it is clear that working on-call was an error-producing condition for some slips, RBMs and KBMS. Lapses were associated with electronic prescribing and prescribing on unfamiliar drug charts. KBMs were an important issue during the first few weeks of starting a post.

4.4 Overarching themes

After carrying out the analysis according to Reason's theory, it was clear that there were overarching themes which ran through all types of error some of which are highlighted in tables 8 and 9. The next section discusses some of these main themes in more detail.

4.4.1 Prescribing support and workload

Busyness and rushing were major error producing conditions for all types of errors. Busyness was usually a result of a high workload and a lack of staff. FY1 trainees were often working without support and prescribing for many patients. Lack of support from their senior colleagues was associated with some doctors' errors. Interviewee 3, for example, felt she did not have sufficient time to complete all her jobs and sometimes she did not have her SHO or registrar available for support, although she was reluctant to criticize:

"I'm always in a hurry, erm, there's just not enough time to do all the jobs that I've got to be honest. Sometimes, erm, I don't always have, like, my SHO and registrar always available. I can't really, I shouldn't really blame them, I'm not blaming them it's just my, I don't know." Interviewee 3 (medical school F)

Some foundation trainees recalled that, at the time of the error, they were the only house officer on the ward:

"...the other one that sort of sprang to mind was the fact that, erm, again it was a situation where I was covering, cos I was the only house officer."

Interviewee 12 (medical school E)

Interviewee 1 was annoyed because he felt the SHOs were not pulling their weight and leaving everything to him:

"...there's things like TTO's and SHO's are supposed to help out with that but they don't, so everything falls to the House Officer." Interviewee 1 (medical school C)

Interviewee 22, who worked on a surgical ward, described how, when he approached seniors for advice, he felt he was annoying them:

"Q: What made you think that you might be annoying them?"

A: Er, just because they'd say, you know, first words'd be like, "Hi. Yeah, what is it?" you know, "I've scrubbed." That'll be like, sort of, the introduction, it wouldn't be, you know, "Any problems?" or anything like that. You know, the fact is, they're saying they're scrubbed and meaning they're busy, you know, and they're pulling off the table, erm, sort of... Rather than just being... I don't know, it just, er, it just doesn't sound very approachable or friendly on the phone, you know. They just sound rather direct and, and that they were busy, I was inconveniencing them rather than, you know, asking a general question..." Interviewee 22 (medical school O)

Accessing advice from seniors appeared to more problematic for FY1 trainees working in surgical specialities:

“It’s difficult when you’re doing surgery as a house officer. It’s, you do have, you have the support of the registrars, but a lot of them are in theatre, or, you know, and they’re difficult to get hold of...” Interviewee 13 (medical school H)

As well as their more general busyness, there were specific times that were particularly associated with high workload and propensity to errors; working on-call was one of them. Interviewee 10, whilst working on-call, accidentally mixed up two patients’ charts and ended up prescribing medication for the wrong people. When this was further explored during the interview, he felt that having many jobs to do had a role in his error:

“I was just being bleeped left right and centre to go and do other things plus admissions in SAU.” Interviewee 10 (medical school O)

FY1 trainees also found ward rounds especially stressful, as they often had to carry out a number of tasks simultaneously. Several doctors discussed examples of errors that they had made during this time:

“The consultant had said on the ward round, you know, “Prescribe this,” and you have, you’re trying to hold the notes and hold the drug chart and hold everything and try and write ten things at once,...I mean, normally I would check the allergies before I prescribe, but I think it was just really, it gets really hectic on a ward round.” Interviewee 18 (medical school G)

4.4.2 Prescribing pressure

As well as busyness, these doctors often felt under pressure when presented with several prescribing tasks simultaneously by nursing staff:

“One of the things you always get asked to do is people just, the nurses will put a stack of four fluid charts in front of you when you’re on the ward and say,

“While you’re here can you prescribe these fluids?” Interviewee 5 (medical school M)

Interviewee 3 often forgot to sign prescriptions or write stop dates on prescriptions for IV infusions that she had written, because she had had to rush, describing having nurses ‘push scripts under her nose’:

“When you’re in a hurry people just tend to push scripts under your nose and say, you know, “You need to get that signed, you need to prescribe that,” but you don’t think about, you know, following it up or, you know, that kind of thing.” Interviewee 3 (medical school P)

Occasionally, nurses requested inappropriate prescriptions. Interviewee 12 was asked to prescribe paracetamol by the nursing staff but subsequently found out that the patient had already been prescribed it:

“...they [the nurses] sort of say, “This person’s got a headache. Will you prescribe paracetamol?” and you go to do it, and I’ll, sort of, start writing it and then go “oh are they on it?” and there’ve been a few times where they’ve already been on it.” Interviewee 12 (medical school E)

Nursing staff could also influence FY1s’ prescribing decisions, which on occasion resulted in prescribing errors:

“So, I stupidly stopped her pill, partly because I listened to one of the male nurses on the ward, who was like, “Oh, yeah, she’s, she just takes this pill all the time. Shouldn’t she have a break?” And I was, “Oh yeah, she should.” Interviewee 9 (medical school B)

“I think that happens a lot, actually, as an FY1, nurses make you prescribe things that maybe you shouldn’t, you wouldn’t normally.” Interviewee 13 (medical school H)

4.4.3 Prescribing norms and culture

Some doctors' prescribing errors were only revealed to them when they moved ward or speciality; their previous 'correct' prescribing decisions were deemed 'erroneous' when practising within another environment. Interviewee 1 prescribed a statin and a macrolide to a patient, which was then judged an error by the pharmacist. He reflected on how he must have made this error many times on a previous rotation, which went unremarked:

"I don't think me or any of the Pharmacists or anything, anyone actually realised at all, erm, that they were on both, and that, sort of, carried through all throughout all Orthopaedics, and it's only when I came here and started seeing patients with rhabdomyolysis and everyone was very keen and more medically inclined to stop them that I actually realised, 'Hang on a sec,' what I was doing then probably I should've been stopping Simvastatin." Interviewee 1 (medical school C)

Importantly, he described knowing about an interaction between the drugs, but because everyone else was prescribing the same thing he did not question his previous actions:

"I mean, I knew that Simvastatin can cause rhabdomyolysis and there's something to do with macrolides and simvastatin but it didn't quite put two and two together because everyone used to do that." Interviewee 1 (medical school C)

Another FY1 trainee was told that her prescription for potassium was incorrect, both because the dose was too low and because it should be administered as an IV infusion. The rationale for her decision was that she had followed the treatment regimen that would have been recommended by senior colleagues on her previous ward:

"I think it's just down to me kind of following what I'd done previously, you know, I'd learn from the SHO and registrar on the previous ward and I just kind of carried that over to here... I mean I said to the registrar last week, "Oh

on my old ward we did this.” And he just said, “Oh no, we don’t do that here,”
Interviewee 6 (medical school J)

Whatever prior knowledge a doctor possessed could be overridden by what was the ‘norm’ within a particular environment. Interviewee 13 expressed her confusion with the different prescribing practices she witnessed in different specialities:

“... you’ll find that in different specialities it’s different. Like, when I did surgical on call, for every patient that came in, you’d give them paracetamol, codeine, and PRN tramadol. Now, talking to the pain nurse, you never ever do that, cos you should never ever prescribe codeine and tramadol together cos you don’t know when, how they’re affecting or something like that, but when we were on surgery that was what you did, kind of thing. It’s very strange.” Interviewee 13 (medical school H)

These prescribing norms were often a factor in doctors’ RBMs. FY1 trainees selected a rule that was the norm in a previous speciality but which was inappropriate in their current speciality.

4.4.4 Following orders

Much of the prescribing that FY1 trainees carried out was directed by a more senior doctor. This was a factor in many of the errors recalled by interviewees.

A number of critical incidents arose partly because FY1 doctors followed orders unquestioningly, without going through their normal prescribing process. Interviewee 15 felt relieved when a senior colleague came to help, but then prescribed an antibiotic to which the patient was allergic, despite having already noted the allergy:

“...the Registrar came, reviewed him and said, “No, no we should give Tazocin, penicillin.” And, erm, by that stage I’d forgotten that he was penicillin allergic and I just wrote it on the chart without thinking. I say without thinking, cos it, I had thought of it already, but, erm, I suppose it was because of the

security of thinking, "Gosh, someone's finally come to help me with this patient," I just, kind of, and did as I was told and, and, you know, didn't look at the allergy box for a second time." Interviewee 15 (medical school E)

Similarly, interviewee 16 erroneously prescribed co-codamol to a patient who was allergic to codeine after being asked to prescribe it by a consultant:

"...the Consultant was saying, "We'll write her up for Co-codamol, and then write her up for," I think it was something codeine based, or something like PRN, which I did. Erm, and then after the ward round the Pharmacist on the ward who's absolutely lovely, came up to me and said, "[Dr's Name], erm, I've noticed a few, that you've written co-codamol and codeine, PRN. Erm, but it does say on the front of the chart that she's allergic to codeine. So can you please change that?"...But I think, like, at the time it just, I just didn't look because I was so rushed. I, I think that a lot of the times you do those things because you're just in the middle of the ward round, the Consultant says something, you don't even question it, you don't even look at the front of the chart." Interviewee 16 (medical school D)

The previous quotation demonstrates the multifaceted causes of prescribing errors; interviewee 16 was not only acting unquestioningly on the consultant's orders but was also in a rush and working in a stressful situation.

This theme appears to be related to the strong hierarchical arrangement of the medical profession within hospitals. Interviewee 13 felt that, as an FY1, she could not challenge any decisions that were made:

"Cos if a senior tells you that this is the way you do things, that's the way you do things, and as a FY1 you know, you can't really, unless you've got balls to stand up and say." Interviewee 13 (medical school H)

4.4.5 Interaction with the environment

Prescribing errors made by FY1 trainees were influenced by various objects within the prescribing environment. One such example, frequently mentioned as a factor in memory lapses, was the poor design of drug charts:

“One drawback is things like, erm, anticoagulation erm, prescribing is on a different sheet, which is really poorly designed, it doesn’t have enough room for patient details, and it’s a separate sheet, so it means it can be easily lost.”

Interviewee 14 (medical school K)

Several interviewees who had come from a different Deanery also had difficulty prescribing due to differences in the design of the drug charts, which they felt was a factor in their prescribing errors.

Electronic prescribing was also a factor. Design features of the system were blamed for several errors in one hospital site; however, despite that, one FY1 discussed how he used the system as a back up if a BNF was unavailable:

“We are relatively lucky in [hospital 1] that we have, erm, electronic prescribing on some wards so if, erm, there wasn’t a BNF available on the ward I can log into the computer and, er, go to the drug list and it has the vast majority of the BNF on there.” Interviewee 23 (medical school Q)

The BNF was used by many FY1 doctors yet there were issues surrounding availability and also its usefulness in providing all the necessary information for prescribing:

“...the drugs are there but I think some of them aren’t very clear, I think it’s...like Sando K for example that’s to correct potassium I think you can give it up to two TDS but it doesn’t say that in the...it just says Sando K is used to, you know to, for this reason and it doesn’t give you a specific dose. And sometimes I’m not quite sure whether to give it one TDS or two TDS, it doesn’t give you any, any guidance.” Interviewee 26 (medical school R)

4.4.6 Safety nets

The majority of errors that doctors described did not reach patients, usually because another member of staff detected the error. There was much discussion of this concept of 'safety nets' by interviewees. Interviewee 7 felt they were so efficient that he did not need to worry too much about errors reaching patients:

"I've probably made a few [errors] and, and they've just slipped through, but whether it's just that I've, I haven't written up one regular medication or something, but they've, they normally get picked up so quickly by the experienced staff on the ward that you don't really, you don't really worry too much about it." Interviewee 7 (medical school C)

Nurses and pharmacists were the most important part of the safety net, although senior doctors were also discussed. Nursing staff were regarded as experienced and able to point out errors to the prescriber concerned. Interviewee 11 discussed how she had prescribed the wrong dose of carbocystine on several occasions but this dose was never given as the nurses would alert her:

"But it's never been given at the wrong dose because I'm on a respiratory ward, all the nurses are really experienced in, in that field, so they'll know, it's a drug that's used in respiratory quite a lot, so they'll know, erm, that it's not right to give at that dose and flag it up with me." Interviewee 11 (medical school L)

"...the nurses are quite good at not giving something that says, that they're allergic to." Interviewee 16 (medical school D)

Although there were many occasions when nurses intervened to prevent errors reaching patients, one respondent spoke of an occasion when the net failed and a patient received the same drug twice. Interviewee 8 remembered that the ward sister had apportioned some blame for this error to the nurse:

"I apologised for it [the error] afterwards and the Sister on the ward said that it was, the nurses shouldn't have given both of them as well." Interviewee 8 (medical school A)

Pharmacists were discussed a safety net by all interviewees. They were commonly approached for advice about prescribing and many doctors felt they were a valuable resource:

"I find the Pharmacist really helpful on the ward. I think they, I go to them more than they come to me. I, I ask them about, like, doses of things." Interviewee 16 (medical school D)

The positive experiences that doctors had with pharmacists were highlighted in several interviews. Interviewee 13 had made an inappropriate choice of medication when prescribing for a patient with constipation. She felt that the pharmacist had provided a good explanation of the mechanisms of action of laxatives so that she would not make the same error again:

"I think it was something like a week ago or so I was speaking to a Pharmacist, and I was asking her about it, actually, about general, like, erm, that kind of thing, and she was explaining it a bit better to me and stuff, which was good." Interviewee 13 (medical school H)

The availability of a pharmacist, however, varied between wards. Some doctors knew the routines of their ward pharmacists and would wait until they were available to prescribe medications they were unsure about:

"...my gastro ward had its own pharmacist who was there, I'd say, three hours out of an eight hour day, say, checking the charts...he was really good and if you had a question in your mind about what to do, you knew that he was going to be coming later in the day and you could just ask him. Erm, whereas here, I haven't actually, actually bumped into or seen a pharmacist in the, the month that, well, nearly two months I've been here" Interviewee 18 (medical school G)

The pharmacist safety net was used by some as part of their prescribing process; when they were uncertain of their prescribing they relied on pharmacists to pick up their errors, or fill in gaps in their prescribing. This behaviour was similar to doctors' reliance on nursing staff to pick up on their errors. Interviewee 15 felt that pharmacists would pick up on any omission of patients' regular medications:

"Say I've admitted a patient, I feel confident that if the patient has missed off a medication that they take regularly, the pharmacist is gonna pick it up when they ring the GP and things." Interviewee 15 (medical school E)

This reliance was exhibited with discharge prescriptions too:

"What we, what we tend to do is when we discharge patients we, we go to put all the drugs on the computer and then go to the pharmacy and if there's any problems with any of them, they get flagged up by pharmacy." Interviewee 3 (medical school P)

Potentially, this reliance on the safety net of pharmacists was reinforced by pharmacists themselves, stressed that they would pick up doctors' errors:

"cos I said to the pharmacist who was on the ward, "Oh, I've had to do these again because, er, I've made a mix up," and he said "They would have picked it up anyway." Interviewee 10 (medical school O)

4.4.7 Interviewees' feelings about error

Doctors' feelings towards their errors were explored during the interviews. Commonly, they felt stupid, disappointed with themselves, guilty and frustrated with their actions:

"it's just so obvious, like, I was really annoyed with myself after I did it because I was like, well, I, it must happen a lot. But it's just so obvious. Like, I knew that, I knew that, like, they interact, it's just really annoying."

Interviewee 9 (medical school B)

Doctors felt that they had learnt from their previous errors and often stated that they 'never did it again'. This doctor felt he had learnt an important lesson, that he should ask for help when needed:

"I: how did that error make you, er, feel?"

A: Er, that was quite frustrating cos I really thought I'd understood how to, to prescribe that, but I hadn't, and it's difficult when it's, it's really busy on the ward and you've made a mistake and you're just adding to how much time you have to spend during the day kind of fixing the mistakes you've made, but, yeah, erm. Again, it just made me realise that I've got to ask for help when I need it." Interviewee 11 (medical school L)

However, the same was not always true of minor errors. Some interviewees discussed how they had continued to make the same errors time and time again, usually due to time constraints and knowing that safety nets would detect and rectify them.

4.4.8 Summary

Many of the overarching themes related to the culture of the medical profession and the organisation of healthcare in hospitals. Specifically, there appeared to be a lack of support for foundation trainees who were often left to prescribe in isolation. These doctors found themselves in situations in which support was either absent or unobtainable due to the strict hierarchical culture. Support was particularly problematic when working on a surgical ward and whilst working on-call. Another study, which explored doctors' views of their first year of work, found that doctors felt they had less support in surgical posts than medical posts.¹⁶

FY1 trainees also felt under pressure when on ward rounds and when nurses were pestering them to write prescriptions.

The medical culture meant that relatively junior doctors often acted unquestionably on senior doctors' orders, even when those orders were incorrect.

All interviewees saw nursing staff and pharmacists as providing a safety net. Pharmacists were felt to be particularly helpful in preventing prescribing errors however, they were not always available.

4.5 FY1 Doctors' views on their undergraduate training in prescribing and pharmacology and interviews with medical schools

As part of the interview schedule, doctors were asked about the teaching they had received in prescribing and pharmacology whilst at medical school. Doctors were asked to recall both factual information and also their opinions and feelings towards the education they had received. The types of questions they were asked are detailed in the interview schedule in Appendix F.

To place the above interview data in the wider context of doctors' basic medical education, brief telephone interviews with curriculum leads of their medical schools were also carried out. The findings of both sets of interviews are given in the following section.

Doctors' views of their undergraduate prescribing and pharmacology training varied enormously. Some recounted very positive experiences whilst others held quite negative views of their training. It was also clear that the amount of teaching varied greatly. Some felt that their training was: "*very, very, very basic*" (Interviewee 1 (medical school C)) and others felt prescribing was: "*really drummed into us*" (Interviewee 9 (medical school B)).

4.5.1 Doctors' positive views of their education

Just over a third of interviewees gave an overall positive opinion of their undergraduate teaching in prescribing. Those that held positive views included two FY1 doctors from the same medical school. One of these doctors said that she *“felt when I came out that I was safe as a prescriber”* (Interviewee 20 (medical school B)). When asked why she felt this way she replied:

“...because of my training I think would be the fairest way to put it, and I think that was the point of the training. Erm, one of our exams was safety and practice which you had to, er, choose management options including what you would prescribe and when.” Interviewee 20 (medical school B)

Interviewee 20 had undergone many exams in this subject area and had found this helpful, especially when calculating drugs and writing out prescriptions:

“Q: And how did you find all those exams?”

A: Well, they were just part of the, the course really... I think it's proved helpful now. I'm much more comfortable with calculating drugs and happy with how I would write a prescription and how to make it clear, and I feel that I've not had to work too much to, to fit into the rules here because they were quite similar to what we were doing in terms of capital letters, only write certain abbreviations...” Interviewee 20 (medical school B)

Another doctor from the same medical school also felt that her training was good. She discussed how she believed that FY1 doctors made a lot of errors and therefore it was important to check prescriptions:

“...a lot of the course is really, heavily into, like prescribing and, like, the fact that FY1s do, like, most of the prescribing...because they do most of the prescribing, they make a lot of prescribing errors, so it's important to like, you

know, check stuff over and, so I think it was really good.” Interviewee 9 (medical school B)

Those doctors, who held positive views of their education, often compared their course to the courses undertaken by colleagues:

“Q: How do you feel about the training and teaching you received at medical school in the area of pharmacology and prescribing?”

A: I, I felt it was really good. It’s much better than many other medical schools.” Interviewee 25 (medical school T)

The curriculum lead from medical school T also felt that the course that they provided was good and prepared students well for prescribing:

“Q: So do you think that your curriculum prepares doctors well for prescribing?”

A: We think so, we’ve, I think come quite a long way because we were aware five or six years ago just how ill prepared but there was certainly gaps and so [name] who is our Academic Clinical Pharmacologist has done a lot to revamp the whole curriculum.” CL 18 (medical school T)

Another FY1 doctor who also felt more prepared than his colleagues explained his reasons for this. He felt that both the science and also clinical teaching he received was quite good:

“...in second year we had a, a solid couple of months teaching on sort of pharmacokinetics and you know how all the drugs work and stuff so I have a fairly good understanding of sort of why things do what they do and when you prescribe different things and what you’re worried about and then also in the final year, they just give the more clinical teaching and compared to here where they don’t get any lectures at all and they just do PBL, I think it was a noticeable difference. I mean loads of people here don’t even now you can’t

*prescribe Tazacin to people that are penicillin allergic.” Interviewee 28
(medical school N)*

A doctor from a different medical school also compared her education to that of her colleagues. Her observations were that her prescribing was “*a bit more stringent. Some of them, like, you can't read their writing.*” Interviewee 18
(medical school G)

Interestingly, when the curriculum lead from medical school G was asked if they thought that their course prepared students for prescribing, they stated that it did although they had identified gaps in the basic science. This medical school provided a great deal of practical prescribing teaching and was the only curriculum lead to report a gap in basic science:

“Do we prepare them for prescribing well?...I think they're becoming, technically, quite competent prescribers, but we've identified gaps, and those gaps lie in their knowledge of basic science. So the underpinning knowledge of therapeutics, it's my belief, we need to address, and I'm busy working on that within [medical school G] as we speak.” CL 5 (medical school G)

Doctors discussed specific aspects of the course that they had liked or had found particularly useful. Interviewee 25 commented on how he had enjoyed the inter-professional teaching that he had taken part in as a student:

“A:...we had a multi-professional teaching as well, with the pharmacists.

Q: Okay, how did you find that?

A: That was quite good because, you can compare how the medical students versus the pharmacy students kind of do and they're quite competitive but the pharmacy students just detect the, they can detect the subtle errors that medical students go through...medical, we have, we can, we, we were quite good at general prescribing like the beta-blocker, thiazides, not in diabetics

kind of thing, like they're very good detecting the dosaging errors, the frequency errors and so on, yeah." Interviewee 25 (medical school T)

From the interviews with the curriculum leads it was clear that very few medical schools provided interprofessional teaching. One reason for not providing any such teaching was the lack of pharmacy and or nursing courses at particular university sites. However, one medical school had worked around this issue, managing to provide some interprofessional teaching in certain subject areas:

"We have a big interprofessional conference in year two with [another university] and some units such as Paediatrics, Psychiatry, I think Care of the Elderly, yes Care of the Elderly have components within the units which are interprofessional...." CL 18 (medical school T)

Another curriculum lead discussed how their medical school had teamed up with another university to allow for interprofessional collaboration. However, this was a recent initiative which the FY1 doctor interviewed for the study would not have received:

"We have a thing called the Inter-professional Learning Program, which is done jointly with another university which has 14 other health care professions. Erm, but I'm not sure whether these F1s will have experienced that." CL 3 (medical school F)

Some medical schools, who had access to other healthcare students but did not currently run any inter-professional teaching, were exploring the possibility of introducing some elements to their course. However, one curriculum lead discussed that despite having access to other allied healthcare students, they were not pursuing this kind of teaching due to cost of setting it up:

“Well, I think, I think if you’re gonna do it [interprofessional teaching], you’ve got to get them to be able to talk to each other about a topic that’s meaningful for each of the groups, and then you’re going to, you’re talking about small groups facilitated, and then you’re starting, it’s starting to get very expensive.”

CL4 (medical school C)

Other specific elements of doctors’ undergraduate teaching that were viewed positively were workshops and working with examples of clinical scenarios:

“They give you, like, examples, and we did, like, questions and stuff like that. It was actually quite good...” Interviewee 13 (medical school H)

“...these workshops that we went through, which were really, really helpful, cos it was prescribing on a clinical basis, I don’t think we had enough of that so far.” Interviewee 16 (medical school D)

The curriculum lead from interviewee 16’s medical schools discussed these workshops and how they were aimed specifically at preparing students for the FY1 prescribing role:

“They’re [the workshops] meant to prepare the students for their F1 prescribing activities. So I think they are signing up drug charts, making, looking for interactions, using resources, taking things, you know, they are meant to develop, particularly those prescribing skills.” CL 7 (medical school D)

Some doctors discussed the benefits of their experiences working on the wards. Interviewee 3 felt specific sessions about prescribing and also spending time on the wards was useful:

“I think that mine [prescribing training] was quite good really, erm, we did, you know, like sessions on controlled drugs, erm, sessions on just getting to know the drug boards, erm, and we spent quite a lot of time on the wards so you sort of pick up, pick up things. Like, like, doses and stuff.” Interviewee 3 (medical school P)

Another FY1 trainee who felt that she had benefited from spending time on the wards commented on how this experience had made her less apprehensive when starting the FY1 year:

“I think, I felt slightly, erm, less apprehensive than other people I’ve spoken to because of, erm, our final year we do a ward shadowing placement, so I did quite a lot of looking at drug charts, re-writing drug charts and becoming familiar with lots of drugs” Interviewee 8 (medical school A)

Commonly, however, many FY1 trainees, despite commenting on the positive aspects of their training, would have liked more:

“What we actually received was really good, but it would have been good if we’d received more, I guess, because that’s the mainstay of your job, isn’t it, prescribing, and that’s what you, I think that’s as FY1s, that’s what you mostly get in trouble for, prescribing” Interviewee 13 (medical school H)

4.5.2 Doctors’ negative views of their education

Negative comments on doctors’ undergraduate teaching were, however, more frequent, over half of interviewees being dissatisfied with their training in this area:

“Q: How do you feel about the prescribing teaching and training that you received at medical school?”

A: Erm, I felt it was inadequate. Mainly, I mean, I, the only thing I could safely prescribe when I started was paracetamol and I prescribe lots of, you know, lots of different medications all the time...which I’ve, kind of, done from common sense or, or asking as opposed to actually knowing it” Interviewee 21 (medical school C)

A doctor from a different medical school thought the lack of teaching in this area was inappropriate due to the role FY1 doctors undertook when starting their post:

“I don’t remember ever formally being taught about prescribing and I have talked about it with other students at the time that, erm, we thought that wasn’t, wasn’t very good, really, because we were about to enter a job where you’re doing the majority of, prescribing on your team.” Interviewee 8 (medical school A)

An interview with the curriculum lead of interviewee 8’s medical school revealed that the course had been, and was still being, modified to prepare graduates better for prescribing:

“Q: So do you think you're preparing them well?”

A: In two year’s time, yeah.

Q: Right, so when you've done your changes? What about at the moment?”

A: Not as well as we could do.” CL 1 (medical school A)

There were several comments by FY1 trainees which referred to a general lack of teaching in this topic. This doctor would have liked an entire module in prescribing:

“I don’t think a couple of lectures is, is enough for that, especially with safe prescribing, even though that exam we sat, er, helped see what was safe and unsafe, but it just didn’t cover enough. I think, like, we needed a, a full module in it.” Interviewee 11 (medical school L)

The curriculum lead from medical school L also felt that students: *“need a lot more.”* CL 11 (medical school L)

A few FY1 doctors felt that they were left to pick up the prescribing knowledge they required as they went along:

“...if a nurse says, “Oh prescribe some sedation for this one,” well, you know, you’ve gotta know which one to give, how much to give, will it interact with anything else she’s got? Can she have it? You know, all these factors that

we just never really covered...it's very much you pick it up as you go along."

Interviewee 6 (medical school J)

Many comments made by FY1 trainees focussed on a lack of practical as oppose to theoretical teaching:

"I don't think we received enough. I think it's one of those things that no one felt confident about starting. We had a lot of theory about, you know, pharmacokinetics and how drugs work and... but not necessarily about, sort of, as much practical stuff." Interviewee 14 (medical school K)

The curriculum lead from medical school K echoed this view and discussed how their medical school was reviewing this part of the course because they were aware students were underprepared:

"...we've been having a review of our pharmacology therapeutics and prescribing at the moment. That's been happening over the last two years. The driver for this was a developing perception that students weren't prepared for active prescribing." CL 13 (medical school K)

The timing of the teaching in the undergraduate course was also viewed negatively by some FY1 doctors. Two doctors from the same medical school felt that the teaching they had received was too late on in the course:

"I just felt, for our year anyway, it was a bit left towards the very end and then all sort of cobbled together and thrown at us." Interviewee 22 (medical school O)

The curriculum lead at the medical school was aware of this criticism and the curriculum had been changed to introduce prescribing from year one:

"...we've got a prescribing curriculum now. That, that's only been around for a couple of years...we actually directed it at the, er, the final years but we realised that it was a mistake because, erm, erm, by the time they reach final

year they, er, er, it was a bit late for them to, er, to start catching up shall I say...we're now starting in the, er, in the, in the first year..." CL 8 (medical school O)

Conversely, however, other interviewees commented that early prescribing education was not particularly useful:

"A:...we had like the two day course as well where they just went through common prescribing, well common drugs that we needed to prescribe, it wasn't very useful.

Q: *Why?*

A: Because I mean it wasn't really relevant then, it would have been more relevant now, just before we start the job... But at the time you just weren't thinking about working and what you would be needing to prescribe...you just thought about your finals." Interviewee 30 (medical school L)

As highlighted in the previous quotation, preparing for finals appeared to be the main motivator for undergraduate students. Many comments were made about examinations as discussed later under a separate heading.

Interviewee 26 discussed how he felt that the first couple of years were 'dry' and that there was a lack of structure and focus to her learning:

"...fourth and fifth year everything was a lot more you know self directed, we had a few workshops but I just didn't really feel like there was many focus...and you sort of learnt what you felt that you needed to learn rather than what would actually have been useful..." Interviewee 26 (medical school R)

Another criticism that was voiced by interviewee 12 was that the teaching that he had received focused *"a lot on the rarer interactions rather than the day to day things."* Interviewee 12 (medical school E)

The curriculum lead from the above interviewee's university substantiated his criticisms:

"...we think it's [the module] quite old fashioned, a lot of the, we've tried to, er, update their, erm... The, sort of, drugs they talk about are things that haven't been used for 30 years" CL 6 (medical school E)

Ward shadowing was viewed positively by some interviewees, and less positively by others. Interviewee 30 discussed how she was sent home from shadowing as the doctors where she was placed saw little point in it:

"A: they just, basically you went, you came in and they just said, "Oh just go home" (laughs). So to be honest shadowing wasn't helpful at all.

Q: No?

A: Cos they didn't, the, the doctors just didn't really see any point in it and said, "You'll learn everything when you get here anyway" Interviewee 30 (medical school L)

Another doctor, from a different medical school, compared the length of time he spent shadowing with his colleagues' experiences and felt that prolonged shadows were ineffectual. His reasons included the repetitive nature of the tasks with little opportunity for learning:

"A:...here they do a really, really long shadows, like eight, ten weeks or something, I don't really see what the gain is by shadowing for that long.

Q: Why?

A: Because all the shadows end up doing is just bloods, cannulas and rewriting drug charts and TTO's, and they don't really learn that much." Interviewee 28 (medical school N)

The same doctor, when asked what could have improved his experience of shadowing, suggested *“some actual teaching while being a shadow....”* Interviewee 28 (medical school N) would have been useful.

4.5.3 Pharmacology versus prescribing

Interviewees appeared to distinguish between the more theoretical, basic pharmacology and the more practical area of prescribing. Interviewee 6 felt that, although she had covered a year of pharmacology at medical school, it did not really help with her prescribing:

“The pharmacology course at [medical school J] didn’t actually help with prescribing. It just helps with knowing a little bit more about the drugs that you are prescribing, which is useful, cos, you know, it’s good to know what you’re prescribing, but it didn’t actually help with the prescribing.” Interviewee 6 (Medical School J)

Other FY1 trainees discussed how they had not really used their pharmacology knowledge as an FY1 doctor:

“I’ve been quite careful checking my BNF until I know exactly what the dose is in my head and I don’t have to think about it, I can just write it, that, that’s when I start doing it. But my pharmacology use so far has been pretty limited.” Interviewee 7 (medical school C)

Other comparisons between pharmacology and prescribing were made by FY1 doctors:

“We have a lot of general medical training which there’s a lot of teaching in and around pharmacology but you know, its pharmacology its science based as opposed to prescribing based.” Interviewee 27 (medical school A)

Some interviewees discussed how they had forgotten the teaching they had received in pharmacology, as it came at the start of their medical degree:

“I suppose in the first two years at medical school we had some pharmacology but I don’t remember any of that (laugh).” Interviewee 3 (medical school P)

When discussing what doctors liked and disliked about their course, it was often practical prescribing that was perceived to be lacking rather than the pharmacology:

“I think practical prescribing was a bit lacking and a bit more, from a theoretical point of view, it was really really good.” Interviewee 25 (medical school T)

4.5.4 Doctors’ thoughts on improving undergraduate courses

As highlighted in the previous section, practical prescribing was felt to be lacking or non-existent and many doctors thought this should be the main target for improvement:

“It would have been nice to have more of the more practical prescribing rather than the theoretical prescribing” Interviewee 24 (medical school S)

One interviewee, who wanted more practical prescribing experience, commented on how, unlike doctors, nurses received formal prescribing training:

“...you’ll hear the nurses having to go on prescribing courses and things like that and you think, well, we’ve never probably had a prescribing course....”

Interviewee 29 (medical school C)

In line with previous interviewees, Interviewee 16 felt he had received a lot of pharmacology training, yet he did not use this knowledge and would have preferred more teaching about prescribing in a clinical context:

“I learned quite a lot of pharmacology, and kind of bioavailability, and all that so... And then you don’t use that....And then in these workshops that we

went through, which were really, really helpful, cos it was prescribing on a clinical basis, I don't think we had enough of that." Interviewee 16 (medical school d)

Interviewee 21 (medical school C) wanted more *"hands on prescribing"* and interviewee 29 (medical school C) wanted to know about the *"actual process of prescribing"*.

Several curriculum leads discussed how their medical schools had already implemented changes to their undergraduate courses to make them more practically orientated:

"...the other change we are making is we are making some aspects of the Senior Academic Half-day much more focused on practical issues of prescribing." CL3 (medical school F)

Doctors' views on exactly what they would have liked to have seen more of were explored in greater detail during interviews. A common recommendation for improvement was inclusion of some practice at filling in drug charts:

"Q: What, in what way do you think it can be improved then?"

A: Er, just that you get practice at, at writing on drug cards really, cos there's nothing you get to do, erm, as a medical student back in [name of place]. You don't get that many charts to rewrite or, er... In fact, I don't think I ever got one chart to rewrite or one drug to write on a chart, erm, as a medical student. It's very much hands off." Interviewee 22 (medical school O)

Some medical schools recognised the lack of experience that students had of practical prescribing, including the writing of prescriptions. Curriculum lead F was one of these interviewees; however he pointed out that the curriculum the FY1 we interviewed had experienced had subsequently changed (like many curriculums) to include more practical aspects of prescribing:

“...this group of F1s, most of what they will have experienced is what I would call a combination of classical pharmacology and clinical pharmacology, and only a relatively limited experience of actually how to write prescriptions...” CL 3 (Medical school F)

However, some medical schools had provided our group of FY1 trainees with the opportunity to practice writing prescriptions whilst at medical school. The following interviewee, from Medical School G, discussed the teaching in place at his medical school that allowed students to practice prescribing. He felt that this type of teaching would help FY1 doctors concentrate on the therapeutics aspect of prescribing, rather than worrying about how to actually write a prescription:

“And the programme that we’re on here is one where the intention is to provide the students with repeated practice at prescribing, so that by the time they hit the wards as F1 Doctors, they have written prescriptions so many times that they’re able to think about the therapeutics for that patient, and actually do a medication review as they’re writing the prescription, rather than thinking, “How do I write a prescription?” CL 7 (medical school G)

The above medical school also arranged for feedback to be provided to the students from a clinical pharmacist:

“So on a week by week basis, they should be approaching their clinical pharmacist on the ward, and their designated pharmacist in the hospital, with their prescription saying, “I’ve written this prescription,” and the pharmacist with a, with a check sheet... goes through it and discusses it with them.” CL 5 (medical school G)

However, some curriculum leads were concerned about the clinical governance implications when facilitating prescription writing by medical students. The interviewee from Medical School B deliberated over the use of draft prescriptions, as he believed that students benefited from such practice, yet he was aware of the possible problems to this approach:

“...And whether, with the new, tomorrow’s doctors, erm, recommendations it’ll actually transpire that they will be allowed to write draft prescriptions which are then signed off, erm, I can see all sorts of concerns about that as well but it’s only by really doing it do they remember. Erm, so that, I think, you know, if you were to say where are we going next I, I hope it’s more in that direction and if it can’t be, er, supported, that they’re doing it as draft prescriptions and being countersigned by, by, erm, clinicians then at least having paper practice prescribing in every module I think is what’s required.” CL2 (medical school B)

The FY1 doctors we interviewed often preferred teaching to be clinically focussed; they would have liked teaching that was clinically based, including common scenarios and interactive cases:

“Q: What exactly would you like more of then?”

A: I had the, kind of, one or two sessions with [hospital 13] where it was actually hands on, er, prescribing and I think it, some, things more like that, do you know, common scenarios, erm, that you’re called, called to prescribe, erm, and, and the difficult drugs, you know, knowing how to safely load and alter warfarins, erm, based on INR’s.” Interviewee 21 (medical school C)

Two interviewees discussed how they would have liked to have been taught about common prescribing mistakes:

“...the chap who, from Pharmacy, who taught us, sort of said,” Here are some common errors,” but we never really got anything, sort of, like a... we could do with, like, a sheet of A4 and it’ll just say, like, you know, “These are the common mistakes that people make”...” Interviewee 7 (medical school C)

Being taught about common errors was an element of a couple of medical schools’ curricula but was not the norm. Interviewee 5 discussed how he would have liked junior doctors to point out errors that they had made as an FY1 doctor so that he could be aware of what to look out for:

“...it’d be good if a junior doctor, it’ll never happen people here generally don’t have the time, but if a JHO [junior house officer] took the final year students and when, “Right, I’m gonna dedicate ten minutes to taking you around everyone’s cardex and saying, ‘These are the mistakes I made.’ Look, that drug’s wrong, that dose is wrong, don’t do this when you’re a first, when you’re a JHO.” Interviewee 5 (medical school M)

The doctor quoted above was not the only interviewee to suggest that teaching could be provided by junior doctors and other doctors felt that they were ideally placed to point out practical aspects of prescribing and common pitfalls. Interviewee 24 felt that teaching provided by junior doctors would be more practically orientated than that given by consultants:

“...whenever you had a talk it was...it was very scientific you had all the stuff around it and the practical side wasn’t really concentrated quite as much. I think the only way we can get that is by having like an F1 tutorial on it cos you know or house officer or an SHO tutorial cos they’re the ones dealing with those things and they’re the ones writing the prescriptions and so they’re more aware of the sort of things that we need to know...You know we had tutorials by the consultant on a certain disease and then they’ll go on into the, the management and they just didn’t concentrate on how to like, how to not make errors and how to do it properly.” Interviewee 24 (medical school S)

Only one curriculum lead discussed junior doctor led teaching, although this was a relatively new concept:

“Another thing I should mention about prescribing which we’ve been doing for three years now is, a very, innovative project from foundation year doctors. They, erm, they tutor our fifth years on, erm, scenario based prescribing...”
CL 2 (medical school B)

The possible role that pharmacists could have in teaching was mentioned by two interviewees. One FY1 trainee felt that pharmacists, unlike junior doctors,

were best placed to provide teaching as he felt that perhaps he was being taught 'bad habits':

"Q: Do you think anything could have been improved?"

A: I think they'd be a session with one of the pharmacists, erm, just to sort of go through the, how you're meant to prescribe cos obviously we're being taught by people who've possibly picked up bad habits." Interviewee 23 (medical school Q)

Another FY1 trainee, who had worked in the pharmaceutical industry prior to medical school, thought that spending some time in a pharmacy would be beneficial for students:

"...the way we kind of we're taught medicine now it's all about placements, go to this place, go to that place, stand around, see how things work, I think the vast majority of a lot of medical students would learn a lot from spending a bit of time in a pharmacy..., just to see some of the problems and issues they have to deal with, cos in jobs I've done I've spent a hell of a lot of time in pharmacy, in the past, I think that's influenced my prescribing, influenced how I see things." Interviewee 27 (medical school A)

Interestingly, one curriculum lead discussed how his medical school was intending to implement such a plan because it was felt that pharmacists were good at detecting errors:

"... we're actually planning for them to, er, to work side by side with a pharmacist actually...and the reason we wanted this is because the, er, the pharmacists are much, er, stricter and better at picking up errors and, er, than I suppose most of the doctors are." CL 8 (medical school O)

Some FY1 doctors alluded to a general gap between the teaching they were given regarding the pharmacology of individual medications and the real life

process of prescribing. Closing this gap could improve the undergraduate course:

“So there definitely needs to be a more dedicated system where, you know, not just learning about each drug separately, it’s very much the coming together of all the drugs, like polypharmacy, you know, when they’re 92 and they’re on loads of drugs, then you need to know how they all interact and things like that.” Interviewee 5 (medical school M)

“...there’s definitely a loop that could be closed if you see what I’m saying, it’s like a gap that could be filled in terms of prescribing I think.” Interviewee 29 (medical school C)

The notion of a ‘gap’ between theory and clinical practice was also discussed by curriculum leads. The curriculum lead from Medical School A felt the gap between the medical programme and clinical practice should be overcome, whilst also making sure that this was safe:

“...what I think we need to do is, is to develop that programme further so that we’ve got all the elements of Anatomy, Physiology, Biochemistry, Pharmacology, Genetics put in to the right places and, and made clinically relevant to the students because they, because they don’t have the clinical practice...it’s not till they actually start using the drugs that they really develop their, their clinical practice with them. So it’s trying to, to make that... Get, get over that gap and, and keeping it safe.” CL1 (medical school A)

Some curriculum leads felt that, whilst the preparation of undergraduates for the task of prescribing could be improved, a gap would always exist because they could not prescribe ‘for real’ until after graduation:

“I’m sure we can get better, but I think it, there will always be a slight gap in that learning, erm, unless you, er, until people actually have to do it for real.” CL3 (medical school F)

4.5.5 Examinations

Some respondents discussed prescribing examinations they had sat whilst at medical school. Again, experiences varied from interviewee to interviewee; some had been examined before finals and some afterwards. Some examinations were summative and others were formative. This FY1 trainee sat an exam prior to finals in which a pass mark was required before being allowed to continue the course:

“I had an online module....it was 30, 30 questions, multiple choice, erm, and we had a, you had to go to a, the library, computer room and sit it, er, like, erm, under exam conditions, and, er, that was, that was done about, erm, three months before finals and you progressing towards finals was on the basis that you passed that, er, examination.” Interviewee 12 (medical school E)

Interviewee 11 discussed how, at her medical school, students had to take an exam in prescribing after their finals. She remarked that this was the only examination she had to resit during her time at medical school:

“After finals we had an exam which felt like it had just come out of nowhere because we didn’t feel like we’d been, we’d had enough teaching with it, erm, but my course was a lot of self-directed learning. So, we did, kind of, do a lot of work by ourselves anyway, so we just had to train for it through that, but I did struggle with that exam. I think I had to resit it and that was the only thing I had to resit during the whole of med school.” Interviewee 11 (medical school L)

Her view on this exam was that it should have been part of finals:

“I think it [the exam] should’ve been incorporated into finals because it’s really important.” Interviewee 11 (medical school L)

Interestingly, her view was echoed by the curriculum lead of her medical school:

“I think our view is that, er, a separate summative exam or summative paper as part of finals would be ideal.” CL 11 (medical school L)

Whether or not examination marks counted towards a final mark or prevented a student from continuing had an impact on respondent behaviour.

Interviewee 17 felt that she would have prepared better if the exam was compulsory:

“I think maybe if a) it had been compulsory we might have all worked a bit harder for it. Or b) erm, had it not just been after a three hour exam people probably would have put more of an effort into it. But to be honest our, I, I just was, didn’t have a clue what I was doing.” Interviewee 17 (medical school F)

When curriculum leads were asked about assessment, many said prescribing was part of objective structured clinical examinations. However, there was a feeling that prescribing should also be made a more significant part of log book/portfolio/record of training assessments. Curriculum lead 14 discussed how, despite having a prescribing station in final year, he was *“keen to beef that up.”* CL 14 (medical school S)

4.5.6 Doctors’ expectations

Despite a clear call for more practical teaching about prescribing, respondents were very cognisant of how difficult it was to teach prescribing. Most felt it would be impossible to be taught everything. Interviewee 11 felt more teaching might have benefited him but felt this would not be feasible for every possible prescription:

“Maybe if we’d had a bit, a bit more teaching, but, I don’t know, I guess you can’t have teaching on how to prescribe every single drug. It’s a difficult one.” Interviewee 11 (medical school L)

As mentioned previously, having no experience actually prescribing whilst a student was felt to hinder learning and this FY1 doctor felt it was difficult to ask students to learn about something they did not do:

"I think it's very hard to ask them to, well to ask medical students to learn about prescribing. Cos you don't, it's not anything you do as, you need to do as a medical student." Interviewee 16 (medical school D)

This theme was echoed by some curriculum leads. One curriculum lead discussed how the demands on FY1 doctors were unreasonable because of the lack of support and supervision they are given:

"...as they can't do it [prescribing] for real we can't sign them off as being competent prescribers and we never will be able to. It's rather like flying an aeroplane, I mean the first time you fly the aeroplane, by yourself, if it is with passengers in the back that is foolish, but that's actually what we're asking doctors to do. We're not giving them the support and supervision that is necessary after they've graduated, and we're placing completely unreasonable demands upon them." CL 12 (medical school H)

However, a couple of FY1 doctors were of the mind that ensuring that prescriptions were checked and having good safety nets was more important than being taught everything:

"Erm, there's not really much you can do, apart from just ensuring that people check their BNF every time, because it'll normally get picked up, but obviously one in a hundred's gonna get through and it's gonna cause problems."
Interviewee 7 (medical school C)

"...you're doing a medical degree rather than a pharmacy degree so they can't concentrate everything on prescribing and that's why they...I think they have so many safety nets in our prescribing and also they always ask you to ask and check the BNF so I'm not sure if any more could be done in our training I think it's, it's left up to the individual." Interviewee 24 (medical school S)

4.6 Transition from medical school to the FY1 year

The lack of day to day prescribing training may be one reason why doctors found it difficult to link knowledge gained at medical school with the actual task of prescribing in the FY1 year. Many doctors alluded to the problematic nature of the transition between medical school and the FY1 year:

“I mean, there’s always a sharp transition from, you know, not doing any prescribing to suddenly having a responsibility to doing that.” Interviewee 1 (Medical School c)

One doctor described his experience of the transition from medical school to the FY1 year as “terrifying” and “a shock”. His reasons for this were explored by the interviewer:

“Q: Why was that a shock?”

A: Because you've got, like, 90 patients that are all sick, all of them, and everything needs to be arranged for right then, erm, and it was a very old school style team so it was difficult to ask your seniors' help unless people were dying.” Interviewee 20 (medical school B)

The transition between undergraduate education and the FY1 year was felt by many to be difficult because prescribing was a task they had never been able to do before:

“Q: How did you find the transition between medical school and here as regards prescribing?”

A: Erm, very difficult because, I mean, obviously, you, you know, as a student you don't have to prescribe anything and, er, any, any, anything I'd ever do regarding prescription would be, maybe, drug rewrites and to help out the FY1's, but even then, you know, you're copying, er, you're not, you're not

actually prescribing yourself, erm, and there's a massive difference there so it was, er, it was difficult to adjust." Interviewee 21 (medical school C)

A doctor who had a previous degree in pharmacology discussed how even he found the transition difficult:

"Q: how did you find starting work as an FY1 and prescribing?"

A: Do you know what, it's funny you should ask that question cos I always thought I was really comfortable with drugs and you know, because of my background and I've spent so much time sort of in or around that environment, but when it's you and now you're the one who's responsible for giving this person the drug, you kind of take things a little bit more seriously." Interviewee 27 (medical school A)

A sense of responsibility and a realisation of the possible consequences of prescribing dawned on doctors as they entered the FY1 year:

"I think we just weren't aware of how bad things could be till you prescribe wrong, you know. Because, now I know you can probably kill someone with the wrong medication or something like that and it wasn't the obvious thing in medical school, you know it's always like, 'oh wrong' drug, or something like that, but they don't say that you could probably kill this guy, you know."

Interviewee 25 (medical school T)

Interviewee 22 also found the transition from being a student to an FY1 doctor a big leap. He felt this was because he had been handled with 'kid gloves' as a student doctor, and not allowed to do many tasks whilst on placement:

"Q: And how did you find the transition from student to F1?"

A: Quite a leap actually, quite a leap, quite a big, quite a big jump, quite a big jump. Quite a big jump. But as I say, I think that's more to do with the fact

there's been so much kid gloves for the last five years" Interviewee 22
(medical School O)

There appeared to be a mismatch between FY1 doctors' views of the training they received at medical school, and the expectations upon them when actually working. Interviewee 6 felt it was *"just something they kind of expect you to know."* (Medical School j) and interviewee 30 felt that *"they don't really prepare you for it; they just kind of throw you in."* Part of this difficulty was based on putting into practise what was learnt at medical school:

"It's dead difficult to, like, I'm sure they've done, they did quite a good job but until you're doing it everyday you really don't have a good grasp I think of it, of what you should be doing." Interviewee 3 (medical school P)

Some FY1 trainees felt teaching which took place before being able to put it into practice was not useful. Interviewee 5 felt the 'bringing together' of the information that they had learnt would have been beneficial.

"... With things like blood pressure, drugs and, you cover that in lectures in medical school, but it doesn't mean anything when you start the job....I mean they might brush over what drugs to give in medical school but when you actually start, you know, you forget a lot of that." Interviewee 6 (medical school J)

One way that this transition might have been eased was discussed by Interviewee 18, who liked the idea of receiving written information as soon she started on a new ward:

"...maybe a manual or little handbook that you could read. Cos I know some other of my colleagues, when they started a job, the department gave them a little, like, you know, "Idiot's guide to how to work on this ward," and that would have just... You know, cos you don't feel stupid if you can go home and read a little booklet and it just, you know, you don't have to feel like you're in deep water..." Interviewee 18 (medical school G)

One reason for her favouring this approach was that she wouldn't feel stupid if she could go home and read information in her own time. As discussed in a previous section, 'image' appeared to be of great importance to these junior doctors. The early expectations that doctors placed upon themselves, therefore, could lead to errors. This expectation decreased as doctors became more comfortable:

"I suppose it's, it's feeling more secure in, in your position as a, as a Doctor whereas when I first started it was all, kind of, like, 'This is how I'm supposed to be, this is what I'm supposed to know,' whereas now I'm feeling a lot more comfortable doing the jobs" Interviewee 2 (medical school H)

A lack of support when making the transition was experienced by one FY1 trainee who felt that his transition was particularly difficult due his change of Deanery:

"...the House Officer that I should have got a handover from before I started the job had taken annual leave in the last week...so I had no, sort of, you know, orientation to the ward, no shadowing experience, on this hospital. Erm, and the Consultant that I was under went away to Greece for three weeks. Er, I was just left, er, erm, FDST2 and the registrar was quite junior, but they spent it pretty much in theatres. They didn't really do any ward rounds, so it was a bit on my tod really, er, for those three weeks." Interviewee 22 (medical school O)

Contrary to the above FY1 doctor's experience, another FY1 felt that the transition from non-prescriber to prescriber was made easier because of the support he received from an SHO and nurses:

"I started on like the really busy jobs as well, so from the moment I turned up I suddenly had drug cards shoved in front of my nose and, "Can you just prescribe this, can you just prescribe that?" but luckily I was on a ward where the nurses are really, really good and know...sort of helped me quite a bit with

that and my SHO was always there at the beginning." Interviewee 28 (medical school N)

Another interviewee found the transition to the FY1 year frightening as she hadn't trained in the region and she felt quite intimidated by the fact that FY1 doctors from within the Deanery had shadowed at the hospital for some time:

"Q: How did you find the transition between being a medical student and then a doctor?"

A: It was frightening, I didn't feel very prepared for it and I was also quite intimidated because I knew that [Medical school A] students spent a long time shadowing doctors before they started and we didn't do very much of that at all and especially because I hadn't trained in this area I'd trained in [Medical school R] you know and if I wondered how well I'd know the systems and so the whole idea of starting here was, was quite frightening." Interviewee 26 (medical school R)

A lack of familiarity of the drug charts used in different hospital trusts provoked anxiety in doctors who were from another Deanery:

"I was a bit apprehensive cos different hospitals, different charts, different routines, different everything....So, it gets you a bit nervous about the actual drug chart itself" Interviewee 22 (medical school O)

One doctor thought that a teaching session with a pharmacist would have helped her transition from a different Deanery:

"A session with one of the, local pharmacists would have been useful cos having come from out of Deanery, erm, I say there are some, there are drug differences, formulary differences that we use here that we don't use in [medical school Q]." Interviewee 23 (medical school Q)

Although some suggested ways of making the transition easier, several doctors believed there was very little that could be done to improve the situation:

“Q: Do you think anything could have helped that transition?”

A: I don't think so, I don't think anything will, I think it's just experience and time isn't it? I'm a lot more comfortable about doing things now than I was nine months ago when I started, a hell of a lot more comfortable.” Interviewee 27 (medical school A)

4.7 Training within the FY1 year

Prescribing training within the FY1 year was also varied. Many had received training about the actual process of writing prescriptions:

“They made it clear to everybody exactly how to prescribe a drug. Like, not necessarily about doses and timings and things, but how to actually, physically write it on the form, so that everybody can understand and it's legible.” Interviewee 8 (medical school A)

“It was just part of the Tuesday afternoon teaching and it was, erm, just how to prescribe properly, so, prescribing the drugs, using capitals for the drugs and signing it and dating it, and that sort of thing, so taking you through drug charts and what you should and shouldn't do.” Interviewee 10 (medical school O)

Many FY1 trainees viewed the prescribing training they had received since starting the FY1 year positively:

“One of the F1 teaching sessions was prescribing, that was in the first few weeks we were here. Erm, and also some of the virtual learning environment modules have been, had some prescribing teaching. It's actually one of the

better modules. Some of them have been rubbish, but the, the, sort of, prescribing ones are actually quite good." Interviewee 12 (medical school E)

Several FY1 trainees from various different hospital trusts found teaching led by pharmacists particularly helpful:

"...the pharmacists do their, they call it Pharmacy Updates, which is like a little ten minute thing at the beginning of each teaching session and they cover something that they think junior doctors should need to know, like, erm, you know, like opiate prescribing, controlled drugs, and then, like, you know, each week they cover just a little bit, and they, like, put up on the screen, like, "Here's a good prescription, here's a bad prescription. Spot the mistakes...they are short, but they, they're really interactive and, and, yeah, useful, useful tips on, especially, like, tips on what to do if you don't know what to do." Interviewee 18 (medical school G)

Interviewee 19 commented on the usefulness of the induction that he had received on commencement of the FY1 year:

"...we had some sessions, like, quite a few sessions at the pharmacy, erm, who, who came and they gave us, like, drug cards and, you know, they made us, they told us to prescribe certain things and we'd to do it and then they'd go through errors, and, and about TTO's and the controlled prescription charts. Erm, so that just, kind of, gave you a bit of practice...it allowed you to make mistakes in a lecture as opposed to when you go on to the wards. They were very useful, actually. Pharmacy, I think, here, I don't know about other places but I find them very helpful." Interviewee 19 (medical school A)

One interviewee from a different hospital trust wanted more teaching about prescribing during the FY1 year:

"it would be good to get proper, cos a lot of the stuff, to be fair, like, a lot of the stuff that we have for FY1 teaching is a bit, it's not that useful, but prescribing is something that you do all the time. You're constantly doing it, so it would, I

suppose, it would be good to do more prescribing.” Interviewee 11 (medical school L)

The timing of training was also important as some interviewees discussed how they had received useful teaching that but that it had been provided too late in the FY1 year. Interviewee 29 was one such person and she discussed how she had been given training on warfarin prescribing yet she had already learnt how to prescribe it by trial and error:

“We have had training about warfarin in particular although that was six months late, cos we kind of had already learnt how to prescribe warfarin kind of through our own mistakes.” Interviewee 29 (medical school C)

As demonstrated in the previous quote, FY1 trainees also learnt about prescribing informally, as other doctors and healthcare professionals offered advice or when errors that they had made were detected. Interviewee 13 felt that his prescribing had improved after a nurse had left him notes explaining what and how to prescribe:

“...the pain nurse visits, like, three times a week, and so I think as a result of that my prescription for pain has got a lot better cos, you know, she’ll leave you notes and say, “Can we,,,” you know, “Do this instead, this is how we do it,” that kind of thing...” Interviewee 13 (medical school H)

In comparison, many doctors did not receive feedback regarding previous errors that they had made. Interviewee 2, for example, discussed how he found the task of learning from a prescribing error difficult because of this:

“I found this quite difficult, because, erm, I suppose you never really... I reckon I’ve probably made a lot more errors than I can recall, and/or have been aware of, if you know what I mean. So I reckon a lot of the errors just go, sort of, disappear somewhere and either someone sorts them out or changes them.” Interviewee 2 (medical school H)

FY1 trainees felt that they only heard about errors that had caused actual harm:

“There’s so many things that can go wrong, that I suppose that you do make errors all the time and you just don’t notice, unless it causes a problem.”

Interviewee 7 (medical school C)

The lack of feedback regarding errors was particularly troublesome when working on-call:

“...when you're on-call, again it's this whole thing of you'll prescribe something because it, but because it's out of hours, or you don't see them the next day, I guess it doesn't get flagged up, so you're not really ever made aware of things, or as, as to whether you have or you haven't [made an error].”

Interviewee 17 (medical school F)

FY1 trainees discussed how they valued being made aware of their errors as they learned from it; however, there was a feeling that not all errors were pointed out to them:

“...every time you know you've made a mistake it changes the way you prescribe it I think. It's just the ones that you don't know when you've made a mistake.”

Interviewee 29 (medical school C)

4.8 Summary of doctors' views of their education

Doctors from different medical schools had varying experiences in and views of education in pharmacology and prescribing. Some were very happy with what they had received but the majority were not. Their main complaint was a lack of training in practical prescribing. The most frequent recommendation for improving undergraduate courses was to increase the amount of practical, clinically orientated teaching.

Staff at medical schools were aware of some of this discontent, with many curriculums having been modified since our FY1 respondents had graduated. In fact, all the medical schools we interviewed were undergoing or planning some sort of change to their curriculum. Such iterative development of curricula is common in medical schools (and, indeed, in all university departments).

Many FY1 trainees were satisfied with the training they had received in pharmacology yet they felt that there was a gap between this knowledge and the actual process of prescribing. Medical schools were trying to address deficits in practical prescribing and make their teaching more clinically orientated; as they too had identified the gap between theory and practice as a particular problem. Respondents' suggestions to overcome this gap and improve the course included teaching by junior doctors who, they suggested, were better placed to demonstrate the day to day practicalities of prescribing. Furthermore, the role pharmacists could play in such training was highlighted by FY1 doctors, who felt that they may be picking up 'bad habits' from senior doctors. Conversely, the one medical school which felt it prepared doctors well for practical aspects of prescribing believed there may be gaps in their basic science education. That was, however, the exception and not the rule.

Other recommendations for improvement included the incorporation of common scenarios and interactive cases into the undergraduate course. Also mentioned was teaching about common prescribing errors. Some of these approaches to prescribing education were being adopted, though not yet common practice. Practice at writing prescription was a major topic discussed by both FY1 trainees and curriculum leads. Many FY1 doctors felt they would have benefited from more experience of this and all curriculum leads considered it important to ensure students had sufficient practice in writing prescriptions. However the majority recognised that it only became "real" when they took full responsibility for their first prescription.

All curriculum leads indicated that elements of prescribing were assessed in objective structured clinical examination stations, but several also indicated

that prescribing either was, or should be, an essential element of the log book/portfolio/record of training assessment.

Perhaps the greatest challenge for medical schools is to provide a balanced curriculum which covers basic pharmacology, but also links it to practical prescribing with opportunities for students to understand the process of prescribing before entering a post in which prescribing is an essential skill.

The transition from medical school to the FY1 year was particularly troublesome. Most discussed how they had become acutely aware of the responsibility of prescribing, making it a particularly daunting task to begin with. The transition appeared to be worse for those who were unsupported in their new posts and for those who had moved Deanery. Some doctors felt there was a gap between what they were taught and what they were expected to do, especially as they had no experience in prescribing 'for real' before starting work. Suggestions to ease this transition included teaching by pharmacists, and the production of ward information, though some doctors believed it was only experience that could ease the anxiety of prescribing in the FY1 year.

During the FY1 year many FY1 trainees had received some training in prescribing, most of which was provided by the pharmacists and found to be particularly useful. The only criticisms voiced by doctors included the timing of training and the desire for more.

A lack of informative feedback regarding previous prescribing errors was however, a clear shortcoming of 'the system' as a learning opportunity, which would be welcomed by this group of prescribers.

5.0 Discussion

5.1 Principal findings and meaning

Prescribing errors were not solely, or even primarily, a problem of the most junior trainees. Doctors of all grades made prescribing errors, as did non-doctors. The group that had the highest error rate was FY2 doctors, but even consultants made significant numbers of errors. So, deficiencies in undergraduate medical education can only be part of the cause, and changes to it, at best, only part of the solution to prescribing errors. If education is to be a means of reducing errors, it must include higher specialist training and the continuing professional development of consultants as well as education during the undergraduate years and first foundation year. It was noteworthy that a patient's admission to hospital was the time when the prevalence of errors was highest. Whilst the overall prevalence was disturbingly high, only 7% of errors were serious or potentially lethal and very few slipped through the safety net. Both nurses and senior doctors were important components of the safety net but the interventions of pharmacists were a particularly important protection against adverse drug events; in the prevalence study, pharmacists detected approximately 11,000 prescribing errors.

FY1 trainees were the primary focus of interest of this study so our observations pertain primarily to them, but they likely typify the wider culture of clinical care. Respondents needed to be prompted to remember errors, or to identify events that, with prompting, were obviously errors. They used the rather belittling term 'silly errors' and reported deliberate violations. They also described actions by more senior doctors which led to prescribing errors. Those findings reflect unfavourably on the attitude of the medical profession towards this aspect of patient safety. Put differently, a 'safety culture' was strikingly absent in the discourse of early career doctors and the reported discourse of their seniors. Whether by education or other means, our findings show the need to inculcate a stronger safety culture in medical workplaces. James Reason's framework for classifying errors proved to be a helpful way of interpreting the findings. Our respondents reported slips, lapses, rule-based

mistakes, and knowledge-based mistakes. Rule-based mistakes accounted for nearly half those errors -- in other words, the single commonest type of error was to apply the wrong rule or fail to apply the right one. Whereas slips and lapses are skill-based errors, rule-based mistakes result from lack of expertise in defining a problem and applying the correct solution to it. In support of that interpretation, our respondents described instances when automatic thinking overruled the thoughtful choice of a correct prescription. Mistakes of that sort were not primarily due to a lack of declarative knowledge, but to the difficulty of applying knowledge learned during the undergraduate years to practice. Disturbingly, those rule-based mistakes were the ones most likely to slip through the safety net and yet they could often have been prevented by using readily available sources of help such as written information, senior colleagues, or members of other health professions.

Violations were another feature of our respondents' errors. Some violations were situational, and (worryingly) some were routine. In many cases, violations were an error-producing condition that led to subsequent active failures. Whilst violations might be interpreted as an understandable response to a complex and high-pressure working environment, they point again to deficiencies in the safety culture of medical practice and also deficiencies in a system that has to be violated to work efficiently.

Although numerically small, an important new category was 'communication errors', which reflected the failures of people other than FY1 trainees. The perpetrators of those active failures were patients, nurses, and more senior doctors. So, junior doctors making prescribing errors are not working in isolation. They are members of 'communities of practice',¹⁷ who work together towards common goals and share responsibility for them. There were times when the authority, expectations, and behaviours of more senior members of communities of practice led FY1 trainees to change correct decisions to incorrect ones and times when nurses and doctors put FY1 trainees in situations that led to errors, for which the trainee was apparently responsible.

The single most important finding of this research was the complexity of the system within which prescribing errors were made, as illustrated by figures 4-8. The task of prescribing sometimes called for a correct choice to be made between different drugs, taking into account patients' multiple diseases and the potential for interactions between the many drugs they were taking. The factors leading to errors were also complex; for example, each active failure had various error-provoking conditions and latent conditions predisposing to it. The predisposing conditions were often multiple -- for example, a lack of experience, fatigue, stress, and a high workload. Inadequate communication between healthcare professionals was also an important predisposing factor. Latent conditions included reluctance to ask senior colleagues for help in case they appeared incompetent. We first consider individual factors and then consider how they interacted to cause errors.

Individual factors

Knowledge and expertise

Lack of knowledge, unsurprisingly, contributed to knowledge-based mistakes but it was very contextualised knowledge rather than broad principles that was the primary cause of such mistakes. Lack of a day-to-day, working knowledge of individual patients was an important predisposing factor. When knowledge was lacking, it could have been remedied (and on some occasions was) by providing better support and/or trainees being readier to take advantage of it. Of particular concern was when FY1 trainees' adequate knowledge was overridden by the system, notably more senior doctors' instructions. Being busy, having a high caseload, having to rush, feeling tired, having difficulty concentrating, multi-tasking, and feeling flustered all made it hard for respondents to apply knowledge they already had. Misapplication of knowledge also occurred when respondents found routine jobs unimportant or boring. Lack of expertise (a compound attribute, of which knowledge is only part) led to rule-based mistakes.

Aspects of the practice environment

Whilst characteristics of the practice environment discussed in the previous paragraph were common to all types of error, there were other characteristics that seemed to predispose to individual types of error. For example, starting a new post predisposed to knowledge-based mistakes. Being in possession of insufficient or incorrect information at the time of a patient's admission led to communication errors. Being on call contributed to knowledge-based mistakes, skill-based slips, and rule-based mistakes. Working in certain environments -- notably, units with a fast turnover of patients -- led to skill-based slips, as did short-staffing on wards. Unfamiliarity with individual patients led to skill-based slips and rule-based mistakes. Tiredness towards the end of the day led to skill-based slips. Unfamiliar drug charts led to memory lapses. Both the vagaries of one particular e-prescribing system and unfamiliarity with drug charts led to memory lapses. Disturbingly, 'following orders' led to rule-based mistakes. One specific aim of this research was to seek out any impact of equality and diversity issues, and none was apparent.

Some material and organisational features of the prescribing system predisposed to error. Those included (minor but disconcerting) differences between the prescription charts in different hospitals, the one instance of an e-prescribing system that predisposed to error, and the availability and usefulness of the British National Formulary. Norms of on-call working, and the practices of surgical teams, where more senior doctors primarily focused on operative surgery and left junior doctors to attend to other aspects of patient care, were additional features.

Compound factors

Workload, time, and support

Many respondents described how they made mistakes because they were busy and having to rush. That resulted from a heavy caseload, just one doctor covering a ward, and more senior doctors not 'pulling their weight'. It also resulted from having to multitask, and not being supported by senior colleagues. It also resulted from nursing staff applying pressure to FY1 trainees by 'pushing charts under their noses' for immediate attention, giving

them 'a stack of charts' to deal with, and asking them to take clinically inappropriate actions. Senior doctors were at times unreceptive to their trainees' needs for help; time pressure whilst on call and created by seniors' behaviour during ward rounds also predisposed to errors.

Prescribing norms and culture

Instances were reported of habitually wrong prescribing behaviours being shared by all members of a team without any of them being aware of it. Under those conditions, appropriate behaviour on the part of the trainee might be overridden by shared inappropriate norms, or by incorrect orders being passed down to them. Whilst pharmacists provided an important safety net, doctors tended to rely on them to correct errors and felt that pharmacists expected to be relied upon. That is at odds with patient safety being a shared priority within a collaborative team. Whilst doctors sometimes responded to their errors by feeling stupid, guilty, disappointed, or frustrated, and vowed they would never make such a mistake again, there were also occasions when they wilfully continued to violate rules, relying on the safety net to ensure patient safety.

Safety net

The lack of adverse drug events in this study reflected the existence of a well-developed safety net. Nurses and senior doctors played important parts in preventing errors impacting on patients, but the contribution of pharmacists was pivotal. The importance pharmacists as a safety net was strikingly obvious in the prevalence study with a total of 11,077 errors being detected by pharmacists alone.

The impact of education

In order to identify how revised medical education standards could minimise errors, we paid particular attention to undergraduate medical education, FY1 education, and the transition between them.

Undergraduate medical education

Trainees' and curriculum leads' accounts of programmes were reassuringly consonant with one another. From trainees' perspectives, undergraduate

programmes were variable in quality. Instances of good, practical education included a blend of good science with good clinical teaching, appropriate assessments, stringent teaching, and interprofessional education. Less satisfactory experiences were when prescribing education was left to opportunistic learning, was not practical in nature, when theory dominated over practice, when a programme did not incrementally prepare students for practice, and when shadowing placements were of poor quality. There was some critical comment from respondents about pharmacology education not helping their practice after qualification. Not only were staff aware of such deficiencies, but all of them spoke of the importance of improving prescribing education, and many said curriculum reform was under way in their school. Some specific suggestions for improvement included:

- More training in practical prescribing, including filling in drug charts
- Teaching about common prescribing errors
- Clinically focused teaching, including common scenarios and interactive cases
- Training about treating patients on multiple drugs

Respondents suggested pharmacists should be more involved in undergraduate medical education as should junior doctors, who understood the problems faced by newly qualified doctors. Experience of pharmacy practice, as well as medical practice, was suggested. It was suggested the gap between theoretical instruction in pharmacology and practical prescribing should be narrowed. It was also suggested prescribing should be a mandatory component of final examinations, and should be included in portfolio assessment. Nevertheless, respondents recognized it would be hard to close the gap between undergraduate education and the FY1 year completely because it was illegal for medical students to prescribe 'for real'. The challenge that emerged from respondents' narratives was for medical schools to provide a balanced curriculum, which helped medical students learn basic pharmacology, and link it to practical prescribing. Such a programme should provide opportunities to understand the prescribing

process and be familiar with it by the time prescribing became an essential skill.

The transition from undergraduate to FY1 education

Recent medical education research has identified the existence of transitions, and the importance of minimising their negative effects.¹⁸ In particular, a transition from undergraduate education to practice is well recognized, and it has consistently been shown that 'becoming a prescriber for real' is one of its most dominant, and often negative, features.^{19;20} A lack of prescribing training contributed to the emotional pressures of at least some of our respondents' transitions. They described how they became aware of their new responsibilities and the possible consequences of their acts. They used emotionally laden words such as 'terrifying', and 'shock'. A pharmacology graduate noted that even he found the transition difficult. There was a clear mismatch between the education provided in medical school and the performance that was expected of doctors immediately after qualification. Such simple, but important, factors as the differences in drug charts between the hospitals where graduates trained, and those where they practised, added to the stress of transition. There were some negative comments about the support provided when graduates moved to a new Deanery. Suggestions were made about how induction or written information could improve transitions, and it was noted how supportive behaviour by the nurses could also help.

FY1 education

When 'just-in-time' education was provided, it was valued by trainees. Unsurprisingly, the timing of such education was very important and an instance was described when it lost its value because it was provided too late. The contribution of pharmacists to FY1 education and provision of opportunities for supervised and supported practice were regarded as important. Finally, the provision of feedback, whether or not harm ensued from a prescription, was desired by many respondents.

5.2 Strengths and limitations of the research

Our literature review identified just 17 papers reporting causes of and factors associated with prescribing errors, and four examining the effect of educational interventions on prescribing errors. So, this research adds to a rather small evidence-base. The research is 'programmatically'²¹ in that it seeks to answer a research question from several methodological angles and arrive at conclusions by triangulating between them. Qualitative research, albeit observational, allows researchers to make causal inferences subject to future experimental research. Our application of Reason's model to both systematic review and empirical research data gives our findings some coherence. We expanded Reason's model by adding 'communication' as a new category, in which active failures by others were antecedent causes of 'errors by proxy'. The pictogram method we developed allowed us to analyse interacting causes in depth and model the complex system within which prescribing errors were made.

The way we collected empirical data imposed limitations. Interviews are prone to social desirability bias; in other words, respondents may have responded in a way they perceived as being socially acceptable. However, critical incident debriefing has the advantage it 'does not collect opinions, hunches and estimates but obtains a record of specific behaviours'.⁷ So, referencing the interviews to specific prescribing errors contributed to the validity of the method. Nevertheless, it must be acknowledged that qualitative research depends inevitably on self-report. It is also influenced by the subjectivities of a research team. We addressed those issues by using the different perspectives of the team to arrive at a trustworthy interpretation and asking an expert Project Advisory Group to oversee and critique the evolving interpretation. Another potential limitation is that respondents may have been of a certain personality type. Doctors who agreed to take part may have done so because they had particular problems with prescribing, which may not accurately represent a wider population of doctors. For the same reason, it is also possible that doctors who took part were more disposed to be reflective about their prescribing. We attempted to overcome that by recruiting a wide

spread of doctors who had gained different experiences in different specialties. Participants, as discussed in section 4.3, did not give the impression of being anxious about prescribing. Qualitative research does not lay strong claims to generalisability; rather it seeks rich interpretations that could lead to experimental interventions, so further research is needed to test the validity of our interpretation.

5.3 Relationship to previously published research

Trainees' lack of experience in completing prescriptions before they start work is a well recognised problem,²² as is the inappropriate satisfaction of some of them with writing a prescription that 'looks about right'.²³ Although trainees in other studies said they wanted more practical teaching,²⁴ during undergraduate education, at least, they needed the pressure of a summative assessment to motivate them to take it up.²⁵ A study that explored junior doctors' experiences and responses to error found that learning was maximised when errors were formally discussed and constructive feedback was given,²⁶ although Teunissen and colleagues have shown that trainees' openness to negative feedback depends on whether their primary motivation is to be seen to be competent, or to learn from their mistakes.²⁷ It has been said that the medical culture is one that focuses on drug selection, which may explain why patient-specific errors are more common than drug selection errors.²⁸ As far as reducing prescribing errors is concerned, the World Health Organisation has addressed the problem of careless prescribing by publishing a guide to rational prescribing, which includes the step of checking the suitability of a drug before prescribing it.²⁹ The introduction of a standard drug chart in Australia made it possible to provide uniform training in medicines management and reduce the frequency of prescribing errors.³⁰ Wales also has its own 'all-Wales drug chart' which was approved in 2004.³¹

Our finding that errors occur within a complex system fits well with recent interest in the application of complexity science to clinical care³² and medical education.³³ Framing the prescribing system in that way makes education, the primary focus of the present research, just one of many inputs into prescribing

behaviour, the individual contributions of which are hard to predict and may be hard to quantify. Whereas simplicity assumptions would predict a linear dose-effect relationship between the amount of education trainees receive and their error rates, complexity assumptions would not support that prediction because inputs and outputs are not necessarily in a linear relationship. Moreover, multiple other interacting factors might modulate the effect of education and might be more effective targets of educational interventions than FY1 trainees' prior undergraduate education. 'Systems thinking'³⁴ is a management approach that moves away from simplicity assumptions to considering systems in the round and considering carefully how to make them function to better effect. So, for example, interventions to reduce prescribing errors might be more effectively focused on conditions that pertain in the workplace at the time a prescription is written – the design of the drug chart and availability of a formulary - than on practitioners' prior learning. Small changes, complexity science predicts, might make big differences and vice versa. Moreover, interventions to reduce prescribing errors are likely to be complex, with a number of inseparably linked components. Rather than seeking to test interventions analogous to the comparison between active pill and placebo, research is likely to evaluate, in depth, the effects of complex interventions.³⁵ Since it is likely practitioners in the UK healthcare system will have heavy workloads for the foreseeable future, an intervention that standardises prescription charts, makes support systems more readily available in the heat of busy practice, inculcates a safety culture, and encourages trainees to challenge instructions from more senior doctors that they disagree with will likely be needed to reduce the prevalence of errors.

6.0 Recommendations

This research has identified five main targets for interventions to improve patient safety by minimising prescribing errors. Because of the dearth of prior evidence about the causes of prescribing errors and efficacy of interventions, these recommendations are made with the proviso that exploratory research will be required to demonstrate their efficacy. The targets are:

- Clinical working environments
- Undergraduate medical education programmes
- Foundation Year 1 education
- Other parts of the medical education continuum
- Interprofessional education

6.1 Clinical working environments

Problem statement

Factors in practice environment that included heavy workloads, being insufficiently supported, being reluctant or not knowing how to call for help, failing to check information and design of drug charts were primary causes of prescribing errors. The culture of the medical profession and certain practice norms contributed to those failings. The way in which they interacted was complex.

Recommendations

1a A standard drug chart should be introduced throughout the NHS

1b Electronic prescribing systems introduced to support safe prescribing should be monitored closely for new types of error introduced by their use

1c Clear information regarding information services and reference sources should be provided in clinical workplaces

1d Coping strategy training should be offered in undergraduate medical education

1e Clinical governance systems should make clear to senior doctors their duty to exemplify good practice and not to resolve their lack of competence by delegating prescribing to their trainees

1f Trusts should discharge their responsibility to optimise the working conditions of hard-pressed health professionals to ensure safe prescribing

6.2 Undergraduate medical education programmes

Problem statement

Prescribing errors resulted from a lack of training in practical prescribing, failures to link theory with practice, and a focus on domain-specific knowledge and skills at the expense of generic skills such as seeking help. Feedback to students regarding their prescribing knowledge was lacking. Some FY1 trainees had never filled in a drug chart prior to starting work, a finding reported elsewhere.²² Doctors' unfamiliarity with drug charts was found to be an error-producing condition.

Recommendations

2a Education in and summative assessment of practical prescribing should be part of every undergraduate programme

2b Programmes should be designed to build expertise incrementally from underlying theory to practical knowledge (as is discussed in Domain 5, point 66 in the review of Tomorrow's Doctors), practical skills, and the application of knowledge to problem-solving

2c Commonly prescribed drugs such as analgesics, antimicrobials, and cardiovascular medications should be prominent in the subject matter of undergraduate programmes, and required knowledge should include correct dosing, controlled drug regulations, common prescribing errors, and knowledge of drug formulations and routes of administration

2d Student assistantships should be included as part of undergraduate medical courses. The notion of student assistantships is given in Domain 5 in the review of Tomorrow's Doctors and our findings support this recommendation. 'Defined duties' should include the act of prescribing under supervision.

2e During practical placements and 'shadowing' experiences, undergraduate medical students should be supported in developing problem-framing skills and applying them to safe and effective prescribing

2f During practical placements, undergraduate medical students should spend time with pharmacists so as to gain understanding of the complete prescribing process

2g Point 68 in Domain 5 of Tomorrow's Doctors 2009, states students should have regular feedback on their performance. This domain should include specific feedback regarding undergraduate students' prescribing skills during senior placements.

2h Undergraduate programmes should develop habits of mind which include openness to feedback, willingness to seek help, and willingness to challenge instructions or information from practitioners which the student believes to be incorrect

2i The findings of this study support point 90 in domain 5 of Tomorrow's Doctors, which states that final year students must make recommendations for the prescription of drugs and suggest it should be expanded to include the filling in of drug charts.

6.3 Foundation year one education

Problem statement

'Just-in-time' education and introduction to local policies and practices are seen by trainees as effective educational interventions that are too often absent or ill-timed.

Recommendations

3a Support of foundation year one trainees in learning local practices and procedures pertinent to prescribing should be provided at induction to the foundation year and when moving between posts

3b Education in practical prescribing should be part of foundation year one education

3c Foundation trainees should be given explicit feedback regarding their prescribing practice during foundation education

3d Help-seeking and feedback-seeking behaviours should be encouraged in workplace education and appraisal

6.4 Other parts of the medical education continuum

Problem statement

All grades of doctor make prescribing errors and so unsafe practice is a shared failing, which limits trainers' ability to foster safe behaviour in their trainees.

Recommendations

4a Prescribing practice should be included in higher specialist training and consultant continuing professional development

6.5 Interprofessional education

Problem statement

Doctors at all levels of seniority could interact more effectively with pharmacists, nurses, and other members of health profession teams.

Recommendation

5a Team-based education in safe prescribing should be a feature of in-service education

7.0 Recommendations for future research

Outcome measurement is currently bedevilled by inconsistencies in the methodology of research into prescribing errors. Standardisation of definitions and methods, including severity scales for errors, is prerequisite to the evaluation of any interventions to improve prescribing practice

7.1 Clinical working environments

There is a need for complex intervention research, including the types of education listed above as part of the intervention, to explore ways of improving prescribing practice.

Models of how to deal with work pressures and demands developed in other industries should be identified and applied to clinical working environments.

7.2 Undergraduate medical education programmes

Suitable targets for education research include:

- Definition of appropriate subject matter for undergraduate programmes, including generic skills (such as feedback-seeking, and help-seeking behaviours) as well as disease and problem-specific competencies
- Instructional designs to teach complex skills, borrowing from models that have been effectively implemented in other industries
- Implementation of practice-based learning and effective feedback to undergraduate trainees who are not legally allowed to prescribe,

7.3 Foundation year one education

How, effectively, to:

- Induct foundation year one trainees in safe prescribing
- Deliver effective 'just-in-time' education
- Give effective feedback regarding prescribing errors
- Develop help-seeking and feedback-seeking behaviours

7.4 Other parts of the medical education continuum and interprofessional education

How to develop effective higher specialist and continuing professional education for safe prescribing practice across the medical education continuum

Investigative research to test the models and recommendations proposed in this report in:

- Foundation year 2 education
- Foundation year 1 trainees educated overseas
- Primary care

Effective incorporation of non-medical professionals, including pharmacists and nurses, into team-based learning.

8.0 References

- (1) Lewis PJ, Dornan T, Taylor D, Tully MP, Wass V, Ashcroft DM. Prevalence, incidence and nature of prescribing errors in hospital inpatients: a systematic review. *Drug Saf* 2009; 32(5):379-389.
- (2) Tully MP, Ashcroft DM, Dornan T, Lewis PJ, Taylor D, Wass V. The causes of and factors associated with prescribing errors: Systematic Review. *Drug Saf* 2009; 32:819-836.
- (3) Franklin BD, O'Grady K, Paschalides C, Utley M, Gallivan S, Jacklin A et al. Providing feedback to hospital doctors about prescribing errors; a pilot study. *Pharm World Sci* 2007; 29(3):213-220.
- (4) Ho L, Brown GR, Millin B. Characterization of errors detected during central order review. *Can J Hosp Pharm* 1992; 45(5):193-197.
- (5) Wilson DG, McArtney RG, Newcombe RG, McArtney RJ, Gracie J, Kirk CR et al. Medication errors in paediatric practice: insights from a continuous quality improvement approach. *Eur J of Pediatr* 1998; 157(9):769-74.
- (6) Technical patient safety solutions for medicines reconciliation on admission of adults to hospital. 2007. NPSA; NICE.
- (7) Flanagan JC. The critical incident technique. *Psychol Bull* 1954; 51(4):327-358.
- (8) Reason J. Human error. Cambridge: Cambridge University Press; 1990.
- (9) Buckley MS, Erstad BL, Kopp BJ, Theodorou AA, Priestley G. Direct observation approach for detecting medication errors and adverse drug events in a pediatric intensive care unit. *Pediatr Crit Care Med* 2007; 8(2):145-152.
- (10) Kopp BJ, Erstad BL, Allen ME, Theodorou AA, Priestley G. Medication errors and adverse drug events in an intensive care unit: Direct observation approach for detection. *Crit Care Med* 2006; 34(2):415-425.
- (11) Leape LL, Bates DW, Cullen DJ, Cooper J, Demonaco HJ, Gallivan T et al. Systems analysis of adverse drug events. ADE Prevention Study Group. *JAMA* 1995; 274(1):35-43.
- (12) Dean B, Schachter M, Vincent C, Barber N. Causes of prescribing errors in hospital inpatients: a prospective study. *Lancet* 2002; 359(9315):1373-1378.
- (13) Parker D, Lawton R. Psychological approaches to patient safety. In: Walshe K, Boaden R, editors. *Patient safety: research into practice*. Maidenhead: Open University Press; 2006. 31-40.
- (14) Reason J. Human error: models and management. *BMJ* 2000; 320(7237):768-770.
- (15) Coombes ID, Stowasser DA, Coombes JA, Mitchell C. Why do interns make prescribing errors? A qualitative study. *Med J Aust* 2008; 188(2):89-94.

- (16) Goldacre MJ, Davidson JM, Lambert TW. Doctors' views of their first year of medical work and postgraduate training in the UK: questionnaire survey. *Med Educ* 2003; 37(9):802-808.
- (17) Wenger E. *Communities of practice. Learning, meaning and identity.* Cambridge: Cambridge University Press; 1998.
- (18) Shacklady J, Holmes E, Mason G, Davies I, Dornan T. Maturity and medical students' ease of transition into the clinical environment. *Med Teach* 2009; 31:621-626.
- (19) Prince KJAH, van de Wiel MWJ, van der Vleuten CPM, Boshuizen HPA, Scherpbier AJJA. Junior doctors' opinions about the transition from medical school to clinical practice: a change of environment. *Education for Health* 2004; 17:323-331.
- (20) Wall D, Bolshaw A, Carolan J. From undergraduate medical education to pre-registration house officer year: how prepared are students? *Med Teach* 2006; 28(5):435-439.
- (21) Bordage G. Moving the field forward: going beyond quantitative- qualitative. *Acad Med* 2007; 82(Suppl):S126-S128.
- (22) Han WH, Maxwell SR. Are medical students adequately trained to prescribe at the point of graduation? Views of first year foundation doctors. *Scott Med J* 2006; 51(4):27-32.
- (23) Dobrzanski S, Hammond I, Khan G, Holdsworth H. The nature of hospital prescribing errors. *Br J Clin Gov* 2002; 7(3):187-193.
- (24) Tobaiqy M, Mclay J, Ross S. Foundation year 1 doctors and clinical pharmacology and therapeutics teaching. A retrospective view in light of experience. *Br J Clin Pharm* 2007; 64(3):363-372.
- (25) Scobie SD, Lawson M, Cavell G, Taylor K, Jackson SH, Roberts TE. Meeting the challenge of prescribing and administering medicines safely: structured teaching and assessment for final year medical students. *Med Educ* 2003; 37(5):434-437.
- (26) Kroll L, Singleton A, Collier J, Rees Jones I. Learning not to take it seriously: junior doctors' accounts of error. *Med Educ* 2008; 42:982-990.
- (27) Teunissen PW, Stapel DA, van d, V, Scherpbier A, Boor K, Scheele F. Who wants feedback? An investigation of the variables influencing residents' feedback-seeking behavior in relation to night shifts. *Acad Med* 2009; 84(7):910-917.
- (28) Coombes ID, Mitchell CA, Stowasser DA. Safe medication practice: attitudes of medical students about to begin their intern year. *Med Educ* 2008; 42(4):427-431.
- (29) de Vries TPGM, Henning RH, Hogerzeil HV, Fresle DA. *Guide to good prescribing: a practical manual.* 1994. Geneva, World Health Organisation.

- (30) Coombes ID, Stowasser DA, Reid C, Mitchell CA. Impact of a standard medication chart on prescribing errors: a before-and-after audit. *Qual Saf Health Care* 2009; In press.
- (31) New all-Wales drug chart looks set to increase patient safety. *Hosp Pharm* 2004; 12:185.
- (32) Complexity and healthcare: an introduction. Abingdon: Radcliffe Medical Press; 2002.
- (33) Mennin S. Self-organization, integration, and curriculum in the complex world of medical education. *Med Educ* 2010; In press.
- (34) Senge P. *The fifth discipline: the art and practice of the learning organisation*. London: Century Business; 1990.
- (35) Medical Research Council. *Developing and evaluating complex interventions: new guidance*. 2008.

Systematic review of the prevalence, incidence and nature of prescribing errors in hospital inpatients

**Penny J Lewis PhD¹, Tim Dornan DM PhD², David Taylor PhD³,
Mary P Tully PhD¹, Val Wass FRCGP PhD², Darren M Ashcroft
PhD¹.**

¹School of Pharmacy and Pharmaceutical Sciences, University of Manchester

²Manchester Medical School Education Research Group

³Liverpool Medical School Education Research Group

Correspondence

Dr Penny Lewis
School of Pharmacy & Pharmaceutical Sciences
University of Manchester
Stopford Building
Oxford Rd
Manchester, M13 9PT, UK
Email: penny.lewis@manchester.ac.uk
Tel: +44 (0)161 306 1738
Fax: +44 (0)161 275 2416
Word count: 3745

Table of contents

Abstract.....	4
1. Introduction.....	6
2. Literature search methodology.....	6
2.1 Search strategy.....	6
2.2 Inclusion and exclusion criteria.....	7
2.3 Data abstraction and validity assessment.....	7
2.4 Quantitative data analysis.....	8
3. Literature search results.....	9
3.1 Study characteristics.....	9
3.2 Definitions of prescribing errors.....	13
3.3 Prevalence and incidence of prescribing errors.....	13
3.4 Medications involved in prescribing errors.....	15
3.5 Types of errors.....	15
3.6 Severity of errors.....	16
4. Discussion.....	17
5. Conclusion.....	22

Abstract

Prescribing errors affect patient safety throughout hospital practice. Previous reviews of studies have often targeted specific populations or settings or did not adopt a systematic approach to reviewing the literature. Therefore, we set out to systematically review the prevalence, incidence, and nature of prescribing errors in hospital inpatients. MEDLINE, EMBASE, and International Pharmaceutical Abstracts (1985 - Oct 2007) were searched for studies of prescriptions for adult or child hospital inpatients giving enough data to calculate an error rate. Electronic prescriptions and errors for single diseases, routes of administration, or types of prescribing error were excluded, as were non-English language publications. Median error rate (interquartile range, IQR) was 7% (2-14%) of medication orders, 52 (8-227) errors per 100 admissions, and 24 (6-212) errors per 1000 patient days. Most studies (84%) were conducted in single hospitals and from the USA or UK (72%). Most errors were intercepted and reported before they caused harm although two studies reported adverse drug events. Errors were commonest with antimicrobials and commoner in adults (median 18% of orders (10 studies, IQR 7-25%)) than children (median 4% (6 studies, IQR 2-17%)). Incorrect dosage was the commonest error.

Overall it is clear that prescribing errors are a common occurrence affecting 7% of orders, 2% of patient days and 50% of hospital admissions. However, the reported rates of prescribing errors varied greatly and this could be partly explained by variations in the definition of a prescribing error, the methods used to collect error data and the setting of the study. Furthermore, a lack of standardisation between severity scales prevented any comparison of error severity across studies. Future research should address the wide disparity of data collection methods and definitions that bedevils comparison of error rates or meta-analysis of different studies.

1. Introduction

In recent years, the extent and impact of adverse events in healthcare settings has made patient safety a key aspect of healthcare policy. Specifically, the Harvard Medical Practice study found adverse events in at least 3.7 percent of admissions^[1], mostly due to medication. Adverse drug events (ADEs) can prolong hospitalisation,^[2] increase mortality risk 2 fold,^[2] and cause an estimated 7000 deaths/year in the US alone.^[3] Moreover, it has been estimated that ADEs cost a single teaching hospital \$5.6 million, \$2.8 million of which was preventable.^[4] In the UK, preventable ADEs cost an estimated £750 million nationwide.^[5]

The negative impact of preventable ADEs has thus stimulated attempts to understand the nature and extent of medication errors. They can occur at the prescribing, dispensing, and administration stages of drug use, but are most likely to arise in prescribing.^[6] Research into the prevalence or nature of prescribing errors has found no consistent pattern in the number or types of errors, or medications associated with them. Single-hospital studies found, for example, prescribing errors in 0.4 to 15.4% of prescriptions written in the USA^[7;8] and 7.4 to 18.7% of those written in the UK^[9;10].

There have been previous attempts to synthesize data systematically from studies of prescribing errors.^[11-14] However, they were either limited in scope (such as focussing on a particular patient group^[11;12] or speciality^[13]), concerned predominately with research methodology,^[14] or have incorporated all types of medication error.^[15] None have focussed on the prevalence or incidence of prescribing errors more generally. The aim of this systematic review was, for the first time, to identify all informative, published evidence concerning the prevalence, incidence, and nature of prescribing errors in specialist and non-specialist hospitals, collate it, analyse it, and synthesise conclusions from it.

2. Literature search methodology

2.1 Search strategy

The following electronic data bases were searched: MEDLINE and MEDLINE In-process and other Non-Indexed Citations (1985 - Oct 2007), EMBASE (1985 - Oct 2007), CINAHL (1985 - Oct 2007), and International Pharmaceutical Abstracts (1985 - Oct 2007). The search strategy was developed by two Authors (PL, DMA). Search terms included: error(s); medication error(s); near miss(es); preventable adverse event(s); prescription(s); prescribe; medication order(s); incident report(s); incidence; rate(s); prevalence; epidemiology; inpatient(s); hospital(s) and hospitalization (the search strategy is available from the contact author). The reference lists of all included studies were searched for additional studies.

2.2 Inclusion and exclusion criteria

Studies published in English between 1985 and 2007 that reported on the detection and rate of prescribing errors in prescriptions that were handwritten for adult and/or child hospital inpatients were included. Systematic reviews, randomized controlled trials (RCTs), non-randomized comparative studies, and observational studies were all included. Abstracts were included if they provided sufficient data to calculate

prescribing error rates (prevalence or incidence). Studies that only provided data on electronic prescriptions via computerised physician order entry were excluded. In addition, studies that evaluated errors for only one disease or drug class or for one route of administration or one type of prescribing error were excluded.

2.3 Data abstraction and validity assessment

A data extraction form was designed to extract the following information: year and country; study period; hospital setting; methods (including type of study; sampling and review processes; profession of data collector; means of detecting error); definitions used; the error rate (including the nature of the denominator)(for studies investigating the impact of CPOE only error rates for prescriptions that were handwritten were extracted from the study); and any other relevant information captured by the study such as severity of errors, type of error, and medications commonly associated with errors. Two reviewers extracted relevant data from each publication independently and resolved any differences by discussion. If they could not achieve consensus, a third reviewer arbitrated.

2.4 Quantitative data analysis

The studies retrieved by the search were extremely heterogeneous but it was possible to group them by the type of denominator used and calculate median error rates and interquartile ranges (IQR) across studies. Studies reporting medication errors were only included if it was possible to separate out the rate of prescribing errors. To be included, studies had to report the rate of erroneous orders, errors per admission or errors per patient day. Studies with an estimated denominator were excluded from the analysis of median rates. To facilitate comparison across studies, the latter rates were converted to common denominators: rates per 100 admissions and per 1000 patient days. When publications gave data from two or more studies whose methodology was similar, the results were aggregated into a median rate. We also explored differences between studies of adults and children and examined error rates in relation to methods of detection. The classification scheme of Thomsen and colleagues^[16] provided a framework for extracting and reporting the types of medications involved and the types of errors.

3. Literature search results

The electronic search identified 595 publications. After initial screening of the abstracts, 493 publications did not meet the inclusion criteria. The remaining 114 publications were obtained in full text and assessed for suitability, as shown in Figure 1. Searching of the reference lists of the included publications identified a further 12 eligible studies. In all, 63 publications were included, reporting 65 unique studies. The main reasons for exclusion were: absent or insufficient data to calculate prevalence rates (n=36); data included administration errors, outpatient prescriptions, and/or verbal and electronic prescriptions (n=7); reported rates were of interventions or violations of policy not deemed errors (n=5); and duplication of previously published data (n=3).

3.1 Study characteristics

3.1.1 Country and date

Most studies were conducted in the USA (25/65)^[8;17-40] or UK (22/65)^[9;10;41-58]. Other countries included Canada (n=3)^[59-61], the Netherlands (n=3)^[62-64], India (n=2)^[65;66], Australia (n=2)^[67;68], Israel (n=2)^[69;70], Croatia (n=1)^[71], Belgium (n=1)^[72], France (n=1)^[73], Denmark (n=1)^[74], Thailand (n=1)^[75], and Spain (n=1)^[76]. Over two thirds of studies were published after 2000 (46/65).

3.1.2 Types of hospitals

Fifty-four percent of studies (35/65) were conducted in university-affiliated hospitals, 17% (11/65) took place in general hospitals, and 6% (4/65) were carried out in both types of hospital. Six studies (9%) were conducted in paediatric hospitals. Two studies (4%) did not state the type of hospital.^[25;67] The remainder (11%, 7/65) were conducted in specialist hospitals such as mental health facilities.

3.1.3 Numbers of hospitals

Eighty-four percent of studies (55/65) were carried out on single hospital sites, 11% (seven studies) in two hospital sites, 3% (two studies) in nine sites^[21;56] and 2% (one study) in 24 sites.^[54] However, studies carried out in more than two hospitals were conducted in one speciality only (paediatric intensive care unit (PICU)^[21], intensive care unit (ICU)^[54] and mental health^[56]).

3.1.4 Specialties

Thirty-eight percent (25/65) of studies were carried out only in adult specialities or wards, 22% (14/65) included only children's specialities or were conducted exclusively in paediatric hospitals (including one study conducted purely in neonates^[76]), 23% (15/65) included both adults and children, and the remaining 17% (11/65) did not state the age range of patients.

3.1.5 Study design

Most studies (89%, 58/65) were prospective in design; 11% (7/65) were retrospective. The shortest period of data collection was 4 days^[51] and the longest 9 years.^[32] Twenty-three (35%) of the studies were before and after studies, in which case only data from the baseline or control arm were used. Eleven of these assessed the impact of computerised physician order entry (CPOE) on the number of prescribing errors^[9;20;30;33;41;44;45;49;64;70;72] and the remainder assessed a variety of other interventions such as the participation of clinical pharmacists on ward rounds^[31;40] or the effect of educational interventions.^[10]

Eighty-three percent (54/65) of studies were process-based, meaning they reported the findings of healthcare professionals reviewing prescriptions, usually as part of routine work.^[14] This type of study does not intend to measure harm as the error is detected and reported to the prescriber before reaching the patient. Outcome-based studies only measuring actual patient harm by reporting ADEs^[14] made up only 3% of included studies.^[18;31] A small proportion (14%) of studies were both process- and outcome-based in that they investigated both incident reports (some of which included actual ADEs) and prescribing errors detected on prescriptions.

3.1.6 Method of error detection

Data collectors were most commonly pharmacists (54/65, 83%). The most frequent method of detecting errors (25/65, 38%) was screening of prescriptions. Eighteen percent (12/65) of studies also included prescription or prescription chart review, which was not necessarily part of routine work and which was sometimes carried out by healthcare professionals other than pharmacists. Four studies (6%)^[26;31;41;71] detected prescribing errors by review of patients' medical records and five studies (8%)^[30;58;65;68;75] used incident reporting. Almost a third of studies (27%) used a combination of the above methods and some even included additional methods such as stimulated self report,^[59] medication reconciliation^[61] and interviews with other healthcare professionals.^[42] Two studies did not state how prescribing errors were identified.^[22;62]

3.1.7 Validation review of errors

Seventy-four percent (48/65) of studies employed a process to check the validity of part of or all the prescribing error data collected. The validation approach varied between studies, some (14%, 9/65) using consensus to rate the severity of errors. Fewer than half the studies (42%, 27/65) included review of the errors themselves, such as determination by a panel of clinicians as to whether reported errors fell within the study definitions and classification of those that did. Only 28% of studies (18/65) checked reported errors with the prescribing doctor in order to validate the claim that a prescribing error had occurred. Twenty-three percent of studies (15/65) did not report any process of review.

3.2 Definitions of prescribing errors

The definition of a prescribing error was extremely varied, 42% of studies (27/65) developing their own definitions or modifying ones used in previous studies. Eleven studies (17%) used a definition of prescribing errors developed by Dean et al.^[77] The twelve studies (18%) recording medication errors or ADEs provided definitions accordingly. Of them, two^[24;74] used the American Society of Health-System Pharmacists (ASHP) criteria and two^[26;76] used the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) criteria. Nearly a quarter of studies (23%) did not state any definition.

3.3 Prevalence and incidence of prescribing errors

Five studies^[52;62;67;71;76] either explicitly used prescription charts (with potentially multiple medication orders) or did not clearly state their denominator (whether order or chart). Four studies provided an estimated denominator^[47-49;51] and were therefore excluded from the analysis. All included studies are presented in Table 1.

Many studies (51%, 33/65) reported the percentage of erroneous medication orders, the median of which was 7% (IQR 2-14%). Six studies did not make it clear whether orders were reported as having more than one error and could not, therefore, be included in the calculation.^[17;22;33;39;60;69] Nineteen studies provided a rate of errors per admission, the median of which was 52 (IQR 8-227) errors per 100 admissions. This wide range in rates could partly be explained by different means of error detection, the lowest rate (0.4 errors per 100 admissions) being derived from incident reporting^[75] and the highest rate (323 errors per 100 admissions) resulting from a combination of three methods of error detection.^[46] Eleven studies provided an

incidence of errors per patient days, the median of which was 24 (IQR 6-212) errors per 1000 patient days. The only two outcome-based studies included in this review reported incidences of errors per patient days,^[18;31] the median of which was 9 errors per 1000 patient days. A subgroup analysis of the remaining nine process-based studies gave a median incidence of 116 errors per 1000 patient days. The lowest incidence of errors was given by a study that used incident reports to detect errors^[30] and the highest rate was given by a process-based, prospective study of error in an ICU.^[72]

Subgroup analysis of studies reporting percentage of erroneous orders suggested that errors were more prevalent in adults than in children (median 18 (10 studies, IQR 7-25%) vs. median 4 (6 studies, IQR 2-17%)).

3.4 Medications involved in prescribing errors

Twenty-two studies (34%) detailed the medications most commonly associated with prescribing errors and those providing quantitative data are summarised in Table 2. Four studies gave information about the classes of medication associated with medication errors but class-specific prevalence rates could not be determined.^[18;29;38;59] Antimicrobials, with a median error prevalence of 32% of orders, were the class most commonly associated with error, particularly in children where all five studies found them to be most commonly associated. Other common associations were with cardiovascular (median prevalence, 17%), central nervous system (median prevalence, 8%) and gastrointestinal medications (median prevalence, 8%). Fluids, electrolytes, and parenteral nutrition had a median prevalence of 9%.

3.5 Types of prescribing errors detected

Sixty-five percent of studies (42/65) reported on the types of errors, of which 33, shown in Table 3, provided percentages of error type. Five studies focussed specifically on admission or discharge and were therefore excluded from the table as it was likely the types of error would be quite specific (i.e. errors of omission). Dosage errors were the most commonly reported error (18/33 studies), the remainder being accounted for by incomplete prescription orders, omission of therapy, illegibility, errors in dosage interval, incorrect formulation, drug-drug interactions, and transcription errors. Seven studies^[23;25;33;35;58;65;75] listed the most frequent types of prescribing errors in paediatric practice. Five of the seven (71%)^[23;35;58;65;75] found dosage errors to be commonest, and the remaining two studies found errors of omission to be commonest.^[25;33]

3.6 Severity of detected prescribing errors

Many studies (74%, 48/65) attempted to classify the severity of errors; however, some (8/48) did not distinguish prescribing errors from errors in administration and dispensing. Two studies, which stated they recorded severity, did not report severity data. Of those that reported severity, three studies^[20;63;64] rated severity according to their own modification of the NCCMERP index for categorising medication errors,^[78] one study^[43] used criteria set out by the UK National Patient Safety Agency^[79] to rate severity, and two studies^[19;34] based their criteria on the work of others such as Folli et al.^[23] Remaining studies provided their own classification of prescribing error severity. This disparity made it impossible to compare severity across studies.

4. Discussion

This is the first systematic review of the prevalence, incidence and nature of prescribing errors in hospital inpatients. It shows that a high rate of prescribing errors is an international problem. The median rates of prescribing errors using three different denominators were 7% (IQR 2-14%) of medication orders, 52 (IQR 8-227) errors per 100 admissions and 24 (IQR 6-212) errors per 1000 patient days. A key strength of our review was the range of databases searched. It is possible that studies reporting error prevalence or incidence were published in journals not indexed by the databases. To reduce that risk, we conducted a search of the reference lists of the included studies. However, only studies published in English were included and there may have been studies written in other languages that were not detected.

The reported rates of prescribing errors vary remarkably as demonstrated by the wide interquartile ranges. This variability can be partly explained by differences in study methods; for example, outcome-based studies inevitably yielded much lower error rates than process-based studies as actual patient harm is not an inevitable outcome of a prescribing error. However, that does not explain all the variability as most studies were process-based. The method used to detect errors may have been a more important source of variability; for example, studies relying on incident reports often had very low error rates, likely due to underreporting.^[80] Review of patient records identified more errors but still only those noted in the records and therefore this approach remains vulnerable to incomplete documentation.^[81] Furthermore, the retrospective nature of record review gave little opportunity for follow up. Studies that identified errors during prescription review were likely to be the most comprehensive^[14] and accurate, yet there was still great variation between rates derived from that method of error detection. Furthermore, the use of more than one means of error detection introduced yet further variability, although the higher rates that resulted from more comprehensive ascertainment may have been closer to the actual prevalence.

Another important consideration was inconsistency in the definition of prescribing errors, with most studies using their own bespoke definitions. Even when definitions were given, some were subjective. For example, a prescribing error is 'a prescription not appropriate for the patient'^[9] or 'any omitting or incorrect ordering of a medication that was critical for the overall care of the patient in the judgement of one of the investigators'.^[8] Others, however, were very specific in their definition: 'a prescribing error is an incorrect drug selection (based on indications, contraindications, known allergies, existing drug therapy, and other factors), dose, dosage form, quantity, route, concentration, rate of administration, or instructions for use of a drug product ordered or authorised by a physician (or other legitimate prescriber); illegible prescriptions or medications or orders that lead to errors that reach the patient; or use of non-standard nomenclature or abbreviations.'^[21] Reviews in paediatric,^[12;19] and mental^[13] healthcare have also found large variations in how prescribing errors were defined. This source of variability has resulted in the formulation of a practitioner-led definition of a prescribing error.^[77] That definition was the one most commonly used, albeit in only 17% of studies.

Whilst the evidence base as a whole was characterised by variability, there were specific limitations in individual studies, such as poor classification of errors. Fewer than half of studies reported any system of error validation. Most did not state

whether there was any discussion of errors with the original prescriber. The finding in one study that 13% of errors detected by a pharmacist were not accepted by the prescriber,^[69] suggests a discrepancy between observers' and the prescribers' perceptions of error. Classification of errors by the data collector without the input of others could result in bias. Furthermore, one study showed variability in error detection and classification between data collectors despite training.^[50] Few studies commented self-critically upon this source of potential bias.

Other limitations of the included studies were the short duration of data collection and the use of estimated denominators in some studies. Although not a limitation per se, the location and type of study site may also have affected the reported rates and types of prescribing errors. Some studies were conducted in specific contexts such as psychiatric hospitals^[51] or intensive care units^[54] while others focussed on a particular stage of the patient's stay in hospital such as admission^[25;42;43] or discharge.^[8;28;34] These studies showed higher numbers of particular types of error such as duplication or omission. Furthermore, most studies were on single sites and there were no studies of larger numbers of errors in non-specialist hospitals. With this in mind, future studies could usefully apply the same methods to record prescribing errors across numerous non-specialist sites.

The severity of detected prescribing errors is important information because, without it, we cannot evaluate the potential harm that could result from them. For example, our results have shown that antibiotics are associated with the most errors yet studies have shown that it is cardiovascular medications that are associated with the most preventable adverse drug events.^[16] However, lack of standardisation between severity scales made it impossible to compare results directly.

We found errors of dosage to be the most commonly reported type of prescribing error as was also reported from a systematic review of medication errors in children.^[12] Winterstein et al also found dosage errors to be the most common type of medication error and that most medication errors were initiated during prescribing.^[6] Furthermore, clinical negligence claims are most often associated with errors in dose, strength or frequency.^[5] So, there is an obvious target for preventive measures, some of which are already being put into place by means of computerised physician order entry (CPOE) systems. Previous research in the USA has shown that a computer assisted antibiotic management program can reduce ADEs and costs,^[82] a finding that might be extended to other healthcare settings. Interestingly, some studies we reviewed were designed to determine the effect of CPOE on error rates^[44;49] and they found improvements in dosage errors and errors of omission. However, they also reported errors unseen with paper-based prescriptions, such as double prescriptions.^[72] Work in this area has also highlighted that there can be many unintended consequences of CPOE including both positive and negative effects^[83] As well as improvements in systems, education has been highlighted as an area for improvement.^[6] A survey of junior doctors in the UK found that doctors themselves would welcome more teaching in clinical pharmacology, particularly covering drug dosing.^[84]

What was also apparent in this review was the importance of healthcare professionals in the process of error detection. Pharmacists were particularly well placed to collect data on errors and were commonly recruited for that purpose. Furthermore, a study by

Phansalkar et al^[85] found that pharmacists were the most thorough when conducting chart reviews. Despite this, some errors may remain undetected.

5. Conclusion

Prescribing errors are common, affecting a median of 7% of medication orders, 2% of patient days and 50% of hospital admissions. The majority of included studies were process-based and used pharmacists to collect data. Antibiotics and drug dosages were most frequently associated with errors. However, the ranges around these findings are very broad and, to some degree, are conditional upon each study's purpose, setting, and methods. The lack of standardisation between different studies, especially around definitions and data collection methods, was a barrier to understanding the extent of prescribing errors and is an obvious area of development for future research. If standardisation could be achieved, the results of individual studies could more confidently be combined, providing a clearer picture of the prevalence, incidence and nature of prescribing errors. Despite the difficulty of aggregating error data, our findings highlight that this is an important area for future research, in both methodology and intervention, to ensure patient safety.

Acknowledgements: This study was commissioned by the GMC to contribute to the evidence base informing policy developments. The authors would like to thank Kathryn Bell for her assistance with data extraction.

Conflicts of interest: None

Contributions of authors: The protocol was designed by all authors. The searches were designed by PJJ and DMA and conducted by PJJ. All authors were involved in extracting data from the publications. PJJ and DMA analysed the results and PJJ prepared the first draft of the paper. All authors commented on subsequent drafts.

Tables

**Table 1: Studies reporting error rates per medication orders, per admission or per patient day
(see key at end of table for abbreviations)**

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total orders/ admissions/ patient days	No. prescribing errors	Rate of errors
Aneja, S. et al ^[65] (1992)	India	Paediatric hospital (n=1)	General paediatric ward	2 months	C	P	Process & outcome based	Incident reports	700	17	2.4 Errors per 100 admissions
Barber, N. et al ^[41] (2006)	UK	One teaching hospital & one general hospital (n=2)	Site 1: general surgery ward. Site 2: paediatrics, CoE, surgery, medicine	5 months	A&C	R	Process based	Record review	Site 1:1258 Site2: 836 & Site 1:438 Site2: 248	Site 1::93 Site2: 72	Site 1: 7.4% of medication Site2: 8.6% orders or Site 1:212 or Site2:290 errors per 1000 patient days
Bates, D.W. et al ^[18] (1995)	US	Teaching hospital (n=2)	2 medical & 3 surgical ICU, 4 medical & 2 surgical general care units	6 months	A	P	Outcome based	Chart review & stimulated self report	4031 & 21,412	128	3.2 or 5.9 Errors per 100 admissions or errors per 1000 patient days
Bobb, A. et al ^[20] (2004)	US	Teaching hospital (n=1)	Inpatient and ED	1 week	A	P	Process based	Part of usual screening by pharmacists	17,808	1111	6.2% of medication orders

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total orders/ admissions/ patient days	No. prescribing errors	Rate of errors
Blum, K.V et al ^[19] (1988)	US	Teaching hospital (n=1)	NS	3 months	A&C	P	Process based	Part of usual screening by pharmacists	123,367	2289	1.9% of medication orders
Cimino, M.A. et al ^[21] (2004)	US	Children's hospitals (n=9)	Paediatric ICUs	2 weeks	C	P	Process based	Pharmacist order review, nurse order review and incident report	12,026	1335 ^{§§}	11.1% of medication orders
Colpaert, K. et al ^[72] (2006)	Belgium	Teaching hospital (n=1)	22 bed ICU	5 weeks	A	P	Process based	Pharmacist order review	1224 & 80	331	27% or 4137.5 of medication orders or errors per 1000 patient days
Dale, A. et al ^[46] (2003)	UK	General hospital (n=1)	2 general medical wards	12 weeks	A	P	Process based & outcome based	Part of usual screening by pharmacists & drug history interview	122	394	323 ^{***} Errors per 100 admissions
Folli, H.L. et al ^[23] (1987)	US	Children's hospitals (n=2)	All wards	6 months	C	P	Process based	Part of usual screening by pharmacists	100, (total no. patient days not stated)	479	0.5% ^{†††} or 15.8 ^{†††} of medication orders or errors per 1000 patient days

§§ Calculated from prescribing errors rate reported

*** Data given for control group only

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total orders/admissions/patient days	No. prescribing errors	Rate of errors
Forster, A.J. et al ^[59] (2004)	Canada	Teaching hospital (n=1)	30 bed general medical ward	1 month	A	P	Process based & outcome based for actual ADRs	Chart review, stimulated self report & incident review	543	13	23.9 Errors per 1000 patient days
Fowlie, F. et al ^[91] (2000)	UK	General hospital (n=1)	1 ward	18 months	A	P	Process based	order review	3064	228	7.4% of medication orders
Fox, G.D. et al ^[24] (1997)	US	Teaching hospital (n=1)	All	3 months	NS	P	Process based	Pharmacist order review	197,488	448	0.2% of medication orders
Franklin, B.D. et al ^[50] (2007)	UK	Teaching hospital (n=1)	Medical directorate with 10 specialties	4 months	NS	P	Process based	Part of usual screening by pharmacists	4995	474	9.2% of medication orders
Gethins, B. et al ^[10] (1996)	UK	General hospital (n=1)	5 wards	NS	A	R	Process based	Order review and record review	2000	373 ^{§§§}	18.7% of medication orders
Granberry, H.E. et al ^[25] (2005)	US	NS (n=1)	NS	2 months	C	P	Process based	Pharmacist order review	272	39	14.3% of medication orders
Grasso, B.C. et al ^[26] (2003)	US	Psychiatric hospital (n=1)	All wards	5 months	A	R	Process based	Record review	1448	239	165 Errors per 1000 patient days

††† Figure as published

‡‡‡ Average of two rates given

§§§ Figure includes those errors resulting from the use of trade names rather than prescribing generically

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total orders/ admissions/ patient days	No. prescribing errors	Rate of errors
Hendey G.W. et al ^[27] (2005)	US	Teaching hospital (n=1)	Doctors in medical/ surgical wards & critical care areas	1 month	A&C	R	Process based	Part of usual screening by pharmacists	8,195	177	2.2% of medication orders
Johnson, K.B. et al ^[28] (1996)	US	Teaching hospital (n=1)	3 units	2 months	C	P	Process based	By comparison of discharge summary, prescriptions & medication labels	335	19	5.7% of medication orders
Kaushal, R. et al ^[29] (2001)	US	Teaching hospital (n=2)	9 wards	6 weeks	A&C	P	Process based	Staff reports, order review, record review & chart review	10,778 or 1120 or 3932	454	4.2% ^{****} or 40.5 or 115.5 of medication orders or errors per 100 admissions or errors per 1000 patient days
King, W.J. et al ^[30] (2003)	US	Tertiary care paediatric hospital (n=1)	2 surgery & 1 medical ward	3 years	C	R	Process based & outcome based for actual ADRs	Incident reports	140,897	20	0.1 Errors per 1000 patient days
Leape, L.L. et al ^[31] (1999)	US	Teaching hospital (n=1)	Medical ICU & coronary care unit	6 months & 10 months	A	R	Outcome based	Record review	1892 ^{††††}	24 ^{††}	12.7 Errors per 1000 patient days

**** Study states that it was extremely rare for more than one error to occur during a single order

†††† Includes baseline data for control and intervention group and data for control group post intervention

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total orders/ admissions/ patient days	No. prescribing errors	Rate of errors
Lepaux, D.J. et al ^[73] (2002)	France	Specialist hospital (n=1)	NS	75 days	Unclear	P	Process based	Part of usual screening by pharmacists	15,699	302	1.9% ^{****} of medication orders
Lesar, T.S. et al ^[7:32;86] (1997)	US	Teaching hospital (n=1)	All patients admitted to the hospital	9 years	A&C	P	Process based	Part of usual screening by pharmacists	3,903,433 or 211,635 or 1,715,649	11,186	0.3% or 5.3 or 6.5 of medication orders or errors per 100 admissions or errors per 1000 patient days
Lisby, M. et al ^[74] (2005)	Denmark	Teaching hospital (n=1)	1 medical & 1 surgical ward	4 months	A	P	Process based	Prescription chart review	433	167	38.6% of medication orders
McFadzean, E. et al ^[42] (2003)	UK	General hospital (n=1)	Medical admissions unit only	NS	A	P	Process based	Full order review	60	110	183.3 Errors per 100 admissions

**** Includes unauthorised drugs

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total orders/ admissions/ patient days	No. prescribing errors	Rate of errors	
Morrill, G.B & Barreuther, C. ^[8] (1998)	US	Veterans hospital (n=1)	NS	7 days	NS	P	Process based	Pharmacist order review	668	103	15.4% or 38	of medication orders or of patients with a least one Rx with an error
Oliven, A. et al ^[70] (2005)	Israel	Teaching hospital (n=1)	Department of internal medicine & similar department	6 months	A	P	Process based	Chart review	641	NS	7.5	Errors per 100 admissions
Olsen, S. et al ^[53] (2007)	UK	General hospital (n=1)	Patient cases chosen from 3 general medical & 3 general surgical teams	NS	A	P	Process & outcome based for actual ADRs	Record review, incident reporting & prescription review	288	41	14.2	Errors per 100 admissions
Parke, J. et al ^[68] (2006)	Australia	General hospital (n=1)	All inpatients	12 months	NS	P	Process based	Incident reports	24,174	211	0.9%	of medication orders
Pote, S. et al ^[66] (2007)	India	Teaching hospital (n=1)	3 medical wards	NS	A & C	P	Process based	Chart review & record review	304	157	51.6 or 34% ^{§§§§}	Errors per 100 admissions
Rees, S. et al ^[43] (2007)	UK	General hospital (n=1)	Acute medical assessment unit	NS	A	P	Process based	Pharmacist order review	200	234	117	Errors per 100 admissions

^{§§§§} Had at least one medication error

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total orders/ admissions/ patient days	No. prescribing errors	Rate of errors
Ridley, S.A. et al ^[54] (2004)	UK	Critical care units in both teaching & general hospitals (n=24)	1 unit in each site	4 weeks	A	P	Process based	Prescription review	21,589	3141	14.6% of medication orders
Sagripanti, M. et al ^[55] (2002)	UK	Teaching hospital (n=1)	Surgery wards (& pre- operative assessment clinic)	2 months	A	P	Process based	Prescription review and record review	76	177 errors in 76 patients	232.9 Errors per 100 admissions
Sangtawesin, V. et al ^[75] (2003)	Thailand	Teaching hospital (n=1)	NS	15 months	C	P	Process & outcome based for actual ADRs	Incident reports	32,105	114	0.4 Errors per 100 admissions
Scarsi, K.K. et al ^[40] (2002)	US	Teaching hospital (n=1)	All patients admitted to general medicine	1 month	A	R	Process based	Chart and record review	35	48	137.1 Errors per 100 admissions
Schumock, G.T. et al ^[34;87] (1994)	US	Teaching hospital (n=1)	2 medicine services	60 days	NS	P	Process based	Part of usual screening by pharmacists	294	17	5.8% of medication orders
Shulman, R. et al ^[44] (2005)	UK	Teaching hospital (n=1)	1 unit in each site	9 days	A	P	Process based	Part of usual screening by pharmacists	1036	69	6.7% of medication orders
StClair, A.T. et al ^[35] (1995)	US	Paediatric teaching hospital (n=1)	All	NS	C	P	Process based	Part of usual screening by pharmacists	14,595	356	2.4% of medication orders
Stubbs, J. et al ^[56] (2006)	UK	Mental health institutions (n=16)	All	5 days	A&C	P	Process based	Part of usual screening by pharmacists	22,036	523	2.4% of medication orders

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total orders/admissions/patient days	No. prescribing errors	Rate of errors
Terceros, Y. et al ^[36] (2007)	US	Teaching hospital (n=1)	General internal medicine unit	1 month	A	Control group: R & study group: P	Process based	Record review	40	146	365 Errors per 100 admissions
Togashi, C.T. et al ^[37] (1991)	US	Teaching hospital (n=1)	Intensive care	6 months	A	P	Process based	Part of usual screening by pharmacists	41,776	463	1.1% of medication orders
Tully, M.P. et al ^[45] (2006)	UK	Teaching hospital (n=1)	Site B: heart unit (HU) & whole hospital	1 year	A&C	P	Process based	Record review & chart review	HU: 1279 & whole hospital: 33,012	HU: 100; whole hospital: 3463	HU: 7.7% of medication orders or errors per 100 admissions or 190; whole hosp: 40
Van den Bemt, P.M.L.A. et al ^[63] (2002)	The NLs	1 teaching hospital & 1 general hospital (n=2)	All wards	5 days	A&C	P	Process based	Part of usual screening by pharmacists	3540	351	9.9% of medication orders
Van Gijssel-Wiersma, D.G. et al ^[64] (2005)	The NLs	General hospital (n=1)	32 bed internal medicine unit	3 weeks	A	P	Process based	Part of usual screening by pharmacists	611	124	20.3% of medication orders
Vira, T. et al ^[61] (2006)	Canada	General hospital (n=1)	All acute care units	2 months	A	P	Process based	Medication reconciliation	60	136	226.7 Errors per 100 admissions
Wang, J.K. et al ^[38] (2007)	US	Teaching hospital (n=1)	All paediatric wards	3 months	C	P	Process based	Part of usual screening by pharmacists	16,938	464	2.7% of medication orders

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total orders/ admissions/ patient days	No. prescribing errors	Rate of errors
Webbe, D. et al ^[57] (2007)	UK	Teaching hospital (n=1)	4 wards	9 weeks	A	P	Process based	Part of usual screening by pharmacists	302	73	24.2% of medication orders
Wilson, D.G. et al ^[58] (1998)	UK	Teaching hospital (n=1)	Paediatric cardiac ward & 4 bed paediatric cardiac ICU	2 years	C	P	Process & outcome based for actual ADRs	Incident reports	682	302	44.3 Errors per 100 admissions

KEY

A = Adults
C = Children
NA = Not applicable
P = Prospective
R = Retrospective

Table 2: Studies reporting types of medication associated with prescribing errors (% of all errors)

Reference	Anti-microbials ^a	CVS ^b	CNS ^c	Analgesics ^d	GI	Respiratory ^e	Endocrine ^f	Blood and nutrition ^g	Anti-neoplastics	Anti-allergic
Baci, V. et al ^[71]	27	35	7	NR	NR	7	NR	6	NR	NR
Bobb, A. et al ^[20]	37	12.3	2.9	7.6	3.2	NR	3.2	3.8	NR	NR
Colpaert, K. et al ^[72]	23.5	23	19.8 ^h	NR	NR	NR	NR	NR	NR	NR
Edwards, K.L. et al ^[22]	35	NR	NR	NR	NR	NR	NR	NR	NR	NR
Fijn, R. et al ^{****[62]}	NR	NR	25	NR	20	12	NR	NR	NR	NR
Folli, H.L. et al ^[23]	35.9	1.7	3.1	8.8	NR	11.3	3.8	16.9	0.8	NR
Ho, L. et al ^[60]	23.7	8.3	14.3	NR	6.5	1	5.3	8.9	0.5	NR

***Authors only gave figure for 449/742 of sample of errors

Reference	Anti-microbials ^a	CVS ^b	CNS ^c	Analgesics ^d	GI	Respiratory ^e	Endocrine ^f	Blood and nutrition ^g	Anti-neoplastics	Anti-allergic
Lesar, T.S. et al ^[32]	35.7	18.3	5	10.6	7	4.5	5.8	3.3	NR	1.1
Lustig, A. et al ^[69]	38.7	15.1	NR	NR	5	NR	NR	21.8	15.6	NR
Pote, S. et al ^[66]	29.4	28.1	8.2	3.2	8.6	0.5	9.1	3.6	0.5	3.2
Ridley, S.A. et al ^[54]	12.5	24.2	16.1	1.7	5.3	3.9	4.1	19.9	NR	NR
Sangtawesin, V. et al ^[75]	32.4	8.97	5.77	6.09	8.33	6.41	5.13	18.59	4.49	NR
Togashi, C.T. et al ^[37]	23	15	NR	NR	14	NR	NR	NR	NR	NR
Van den Bemt, P.M.L.A. et al ^[63]	NR	21	32 ^h	NR	20	11	NR	NR	NR	NR

Reference	Anti-microbials ^a	CVS ^b	CNS ^c	Analgesics ^d	GI	Respiratory ^e	Endocrine ^f	Blood and nutrition ^g	Anti-neoplastics	Anti-allergic
Median % value	32.4	16.7	8.2	6.9	7.7	6.4	5.1	8.9	0.8	2.2

^a Antimicrobials include antibiotics and anti parasitics

^b CVS includes antihypertensives, digoxin, diuretics and anticoagulants

^c CNS includes antiepileptics, psychotropics and sedatives

^d Analgesics include anti-inflammatories (incl NSAIDS), opioid and non opioid analgesics

^e Respiratory includes inhalers, xanthine and theophylline

^f Endocrine includes insulin, antidiabetics, corticosteroids and hormones

^g Blood and nutrition contains vitamins, TPN and electrolytes

^h Figure includes opioid analgesics and non-opioid analgesics

KEY

NR = Not reported

Table 3: Studies reporting types of prescribing errors (% of all errors)

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy ^{††††}	Illegible	Medications omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature/ abbreviation	Allergy
Aneja, S. et al ^[65]	41.18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Baci, V.V. et al ^[71]	44.33	35.36	NA	NA	18.21	NA	NA	NA	NA	NA	NA	NA
Bobb, A. et al ^[20]	39.2	20.2	4.7	6.4	3.5	NA	NA	2.9	NA	NA	9.4	6.4
Blum, K.V et al ^[19]	45	27	11	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dean-Franklin, B. et al ^[49]	54	NA	13	6	NA	NA	NA	NA	9	NA	NA	NA

†††† includes exact & similar treatments, duplicate route and same indication

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy ⁺⁺⁺⁺	Illegible	Medications omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature/ abbreviation	Allergy
Dobrzanski,S. et al ^[48]	4.4 ⁺⁺⁺⁺	4.1	12.6 ^{§§§§§}	3.4	NA	1.7	31.8	NA	NA	3.7	NA	0.7
Edwards, K.L et al ^[22]	35	NA	25	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fijn, R. et a ^[62]	62.81	8.5	NA	NA	4.9	3.1	NA	NA	NA	4.9	NA	NA
Folli, H.L. et al ^[23]	82	NA	NA	5.6	NA	NA	NA	1.9	NA	NA	NA	0.4
Franklin, B.D. et al ^[49]	48.4	NA	14	2.2	NA	NA	NA	NA	10.8	NA	NA	NA

++++ overdose only
 §§§§§ includes duplication

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy ^{†††††}	Illegible	Medications omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature/ abbreviation	Allergy
Gethins, B. et al ^[10]	NA	5.6	NA	13.7	11.3	1.1	NA	NA	NA	NA	66	NA
Grasso, B.C. et al ^[26]	10.9	NA	51.8	NA	6.3	5.4	NA	NA	NA	NA	NA	NA
Haw, C. et al ^[51]	1.9 ^{*****}	3.2	43.4	NA	3.9	10.2	NA	NA	NA	NA	3.2	NA
Hendey, G.W. et al ^[27]	42 ^{††††††}	17	NA	34	NA	NA	NA	NA	NA	NA	NA	2
Ho, L. et al ^[60]	18.7	NA	27.7	NA	NA	9.9	NA	NA	NA	NA	NA	NA

***** under dose only

†††††† Includes errors in route

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy ⁺⁺⁺⁺⁺	Illegible	Medications omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature/ abbreviation	Allergy
Lepaux, D.J. et al ^[73]	NA	2.7	NA	3.6	NA	15.9	NA	NA	NA	4.3	NA	NA
Lesar, T.S. et al ^[32]	56.1	NA	NA	4.1	6.1	NA	NA	3.5	NA	NA	NA	14.4
Lisby, M. et al ^[74]	NA	5.5	NA	NA	NA	NA	NA	NA	43.8 ⁺⁺⁺⁺⁺	10	1.2	NA
Lustig, A. et al ^[69]	27.5	NA	NA	NA	NA	NA	NA	NA	NA	1.3	12.5	NA
Olsen, S. et al ^{§§§§§§ [53]}	NA	30	NA	7	NA	NA	50	3	NA	3	NA	NA

+++++ Includes omission of route and dose

§§§§§§ not all errors, only those detected by pharmacy surveillance

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy ^{††††}	Illegible	Medications omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature/ abbreviation	Allergy
Pote, S. et al ^[66]	9.6	12.1	5	1.3	NA	NA	NA	NA	NA	NA	NA	1.3
Potts, A.L. et al ^[33]	2	0.9	74.3	0.23	0.6	1.8	NA	0.23	NA	NA	15.4	0.03
Ridley, S.A. et al ^[54]	4.4	NA	NA	NA	4.7	9.6	2.1 ^{*****}	NA	9.4	8.2	11.2	NA
Sangtawesin, V. et al ^[75]	25.78	NA	NA	3.73	NA	NA	NA	NA	NA	NA	NA	0.62
Scarsi, K.K. et al ^[40]	Intervention group:46.7 Control group:52.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

***** failure to rewrite

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy ⁺⁺⁺⁺	Illegible	Medications omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature/ abbreviation	Allergy
Schumock, G.T. et al ^[34;87]	11.8	41.2	23.5	5.9	NA	NA	5.9	NA	NA	NA	NA	NA
Shulman, R. et al ^[44]	16.9	NA	31	NA	NA	NA	NA	7	11.3	NA	NA	NA
StClair, A.T. et al ^[35]	30.6	NA	28.7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stubbs, J. et al ^[56]	NA	9.8	27.5	NA	1.9	NA	NA	NA	NA	2.7	NA	NA
Togashi, C.T. et al ^[37]	33	NA	18	NA	NA	NA	NA	NA	NA	NA	NA	NA

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy ⁺⁺⁺⁺⁺	Illegible	Medications omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature/ abbreviation	Allergy
Van den Bemt, P.M.L.A. et al ^[63]	5.4	NA	6.3	NA	8	NA	NA	NA	44.1	NA	7.7	NA
Van Gijssel- Wiersma, D.G. et al ^[64]	43	NA	NA	NA	21	NA	NA	NA	NA	NA	NA	NA
Wilson, D.G. et al ^[58]	22.5	9.3	21.5	9.3	NA	2.3	NA	NA	NA	NA	NA	NA

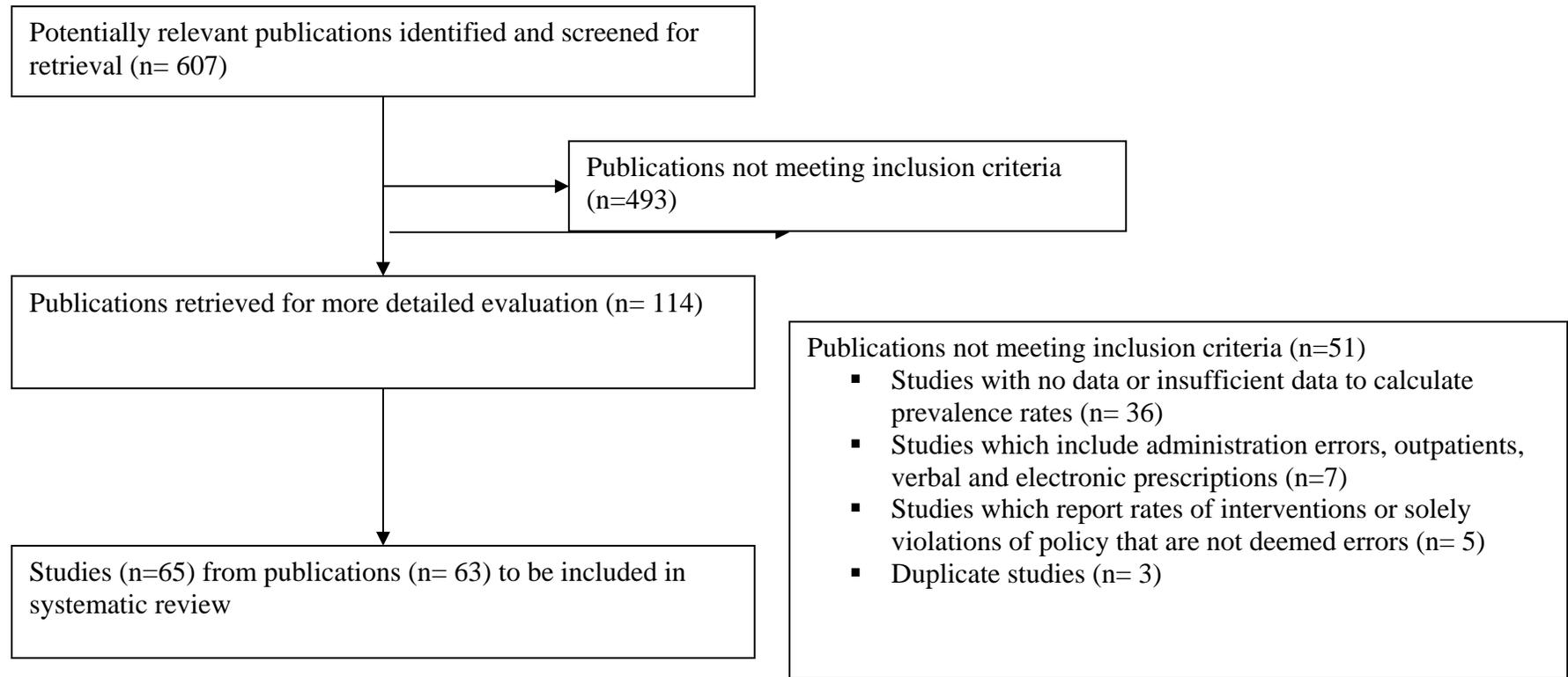


Figure 1: Flow diagram of the screening process

Reference List

- (1) Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med* 1991 Feb;324(6):370-6.
- (2) Classen DC, Pestotnik SL, Evans RS, et al. Adverse drug events in hospitalized patients. Excess length of stay, extra costs, and attributable mortality. *JAMA* 1997 Jan;277(4):301-6.
- (3) Phillips DP, Christenfeld N, Glynn LM. Increase in US medication-error deaths between 1983 and 1993. *Lancet* 1998 Feb;351(9103):643-4.
- (4) Bates DW, Spell N, Cullen DJ, et al. The costs of adverse drug events in hospitalized patients. Adverse Drug Events Prevention Study Group. *JAMA* 1997 Jan;277(4):307-11.
- (5) National Patient Safety Agency. Safety in doses: medication safety incidents in the NHS. 2007.
- (6) Winterstein AG, Johns TE, Rosenberg EI, et al. Nature and causes of clinically significant medication errors in a tertiary care hospital. *Am J of Health Syst Pharm* 2004 Sep; 61(18):1908-16.
- (7) Lesar TS, Briceland L, Stein DS. Factors related to errors in medication prescribing. *JAMA* 1997 Jan;277(4):312-7.
- (8) Morrill GB, Barreuther C. Screening discharge prescriptions. *Am J Hosp Pharm* 1988 Sep;45(9):1904-5.
- (9) Fowle F, Benniw M, Jardine G, et al. Evaluation of an electronic prescribing and administration system in a British hospital. *PharmJ* 2000 Sep;265(7114):R16.
- (10) Gethins B. Wise up to medication errors. *Hospital Pharmacy Practice* 1996 Oct;6:323-8.
- (11) Wong IC, Ghaleb MA, Franklin BD, et al. Incidence and nature of dosing errors in paediatric medications: a systematic review. *Drug Saf* 2004;27(9):661-70.
- (12) Ghaleb MA, Barber N, Franklin BD, et al. Systematic review of medication errors in pediatric patients. *Ann Pharmacother* 2006 Oct;40(10):1766-76.
- (13) Maidment ID, Lelliott P, Paton C. Medication errors in mental healthcare: a systematic review. *Qual Saf Health Care* 2006 Dec;15(6):409-13.
- (14) Franklin BD, Vincent C, Schachter M, et al. The incidence of prescribing errors in hospital inpatients: An overview of the research methods. *Drug Saf* 2005;28(10):891-900.
- (15) Allan EL, Barker KN. Fundamentals of medication error research. *Am J Hosp Pharm* 1990 Mar;47(3):555-71.

- (16) Thomsen LA, Winterstein AG, Sondergaard B, et al. Systematic review of the incidence and characteristics of preventable adverse drug events in ambulatory care. *Ann Pharmacother* 2007 Sep;41(9):1411-26.
- (17) Anderson JG, Jay SJ, Anderson M, et al. Evaluating the potential effectiveness of using computerized information systems to prevent adverse drug events. *Proceedings/AMIA Annual Fall Symposium* 1997;228-32.
- (18) Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events: implications for prevention. *JAMA* 1995;274(1):29-34.
- (19) Blum KV, Abel SR, Urbanski CJ, et al. Medication error prevention by pharmacists. *Am J Hosp Pharm* 1988 Sep;45:1902-3.
- (20) Bobb A, Gleason K, Husch M, et al. The epidemiology of prescribing errors: the potential impact of computerized prescriber order entry. *Arch Intern Med* 2004 Apr;164(7):785-92.
- (21) Cimino MA, Kirschbaum MS, Brodsky L, et al. Assessing medication prescribing errors in pediatric intensive care units. *Pediatr Crit Care Med* 2004 Mar;5(2):124-32.
- (22) Edwards KL, Todd MW, Hogan TT. Evaluation of prescribing errors in a teaching hospital. *ASHP Midyear Clinical Meeting* 1996 Dec;31:61E.
- (23) Folli HL, Poole RL, Benitz WE, et al. Medication error prevention by clinical pharmacists in two children's hospitals. *Pediatrics* 1987 May;79(5):718-22.
- (24) Fox GD, Restino MS, Byerly WG, et al. Identification of prescribing error patterns in a teaching hospital. *ASHP Midyear Clinical Meeting* 1997 Dec;32:139E.
- (25) Granberry HE, Wright CC, Oldag KL, et al. Admission medication order reconciliation for pediatric patients. *ASHP Midyear Clinical Meeting* 2005;40:95D.
- (26) Grasso BC, Genest R, Jordan CW, et al. Use of chart and record reviews to detect medication errors in a state psychiatric hospital. *Psychiatr Serv* 2003 May;54(5):677-81.
- (27) Hendey GW, Barth BE, Soliz T. Overnight and postcall errors in medication orders. *Acad Emerg Med* 2005 Jul;12(7):629-34.
- (28) Johnson KB, Butta JK, Donohue PK, et al. Discharging patients with prescriptions instead of medications: sequelae in a teaching hospital. *Pediatrics* 1996 Apr;97(4):481-5.
- (29) Kaushal R, Bates DW, Landrigan C, et al. Medication errors and adverse drug events in pediatric inpatients. *JAMA* 2001 Apr;285(16):2114-20.
- (30) King WJ, Paice N, Rangrej J, et al. The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients. *Pediatrics* 2003;112(3):506-9.
- (31) Leape LL, Cullen DJ, Clapp MD, et al. Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. *JAMA* 1999 Jul;282(3):267-70.

- (32) Lesar TS, Lomaestro BM, Pohl H. Medication-prescribing errors in a teaching hospital. A 9-year experience. *Arch Intern Med* 1997 Jul;157(14):1569-76.
- (33) Potts AL, Barr FE, Gregory DF, et al. Computerized physician order entry and medication errors in a pediatric critical care unit. *Pediatrics* 2004 Jan;113(1):59-63.
- (34) Schumock GT, Guenette AJ, Keys TV, et al. Prescribing errors for patients about to be discharged from a university teaching hospital. *Am J Hosp Pharm* 1994 Sep;51:15.
- (35) StClair AT, Ofosu JR. Tracking potential prescribing errors in a pediatric teaching hospital. *ASHP Midyear Clinical Meeting* 1995 Dec;30:P202.
- (36) Terceros Y, Chahine-Chakhtoura C, Malinowski JE, et al. Impact of a pharmacy resident on hospital length of stay and drug-related costs. *Ann Pharmacother* 2007;41(5):742-8.
- (37) Togashi CT, Akahoshi PC, Lamp CD, et al. Pharmacist intervention of medication prescribing errors in a university teaching hospital. *ASHP Midyear Clinical Meeting* 1991 Dec;26:P327E.
- (38) Wang JK, Herzog NS, Kaushal R, et al. Prevention of pediatric medication errors by hospital pharmacists and the potential benefit of computerized physician order entry. *Pediatrics* 2007 Jan;119(1):E77-85.
- (39) West DW, Levine S, Magram G, et al. Pediatric medication order error rates related to the mode of order transmission. *Arch of Pediatr Adolesc Med* 1994 Dec;148(12):1322-6.
- (40) Scarsi KK, Fotis MA, Noskin GA. Pharmacist participation in medical rounds reduces medication errors. *Am J Health Syst Pharm* 2002 Nov;59(21):2089-92.
- (41) Barber N, Franklin BD, Cornford T, et al. Safer, faster, better? Evaluating electronic prescribing: report to the Patient Safety Research Programme 2006.
- (42) McFadzean E, Isles C, Moffat J, et al. Is there a role for a prescribing pharmacist in preventing prescribing errors in a medical admission unit? *PharmJ* 2003 Jun;270:896-9.
- (43) Rees S, Thomas P, Shetty A, et al. Drug history errors in the acute medical assessment unit quantified by use of the NPSA classification. *PharmJ* 2007 Oct;279:469-71.
- (44) Shulman R, Singer M, Goldstone J, et al. Medication errors: a prospective cohort study of hand-written and computerised physician order entry in the intensive care unit. *Crit Care* 2005 Oct;9(5):R516-R521.
- (45) Tully MP, Parker D, Buchan I, et al. Patient safety research programme: medication errors 2: pilot study. Report prepared for the Department of Health 2006.
- (46) Dale A, Copeland R, Barton R. Prescribing errors on medical wards and the impact of clinical pharmacists. *Int J Pharm Pract* 2003;11(1):19-24.

- (47) Dean B, Schachter M, Vincent C, et al. Prescribing errors in hospital inpatients: their incidence and clinical significance. *Qual Saf Health Care* 2002 Dec;11(4):340-4.
- (48) Dobrzanski S, Hammond I, Khan G, et al. The nature of hospital prescribing errors. *Br J Clin Gov* 2002;7(3):187-93.
- (49) Franklin BD, O'Grady K, Donyai P, et al. The impact of a closed-loop electronic prescribing and administration system on prescribing errors, administration errors and staff time: A before-and-after study. *Qual Saf Health Care* 2007;16(4):279-84.
- (50) Franklin BD, O'Grady K, Paschalides C, et al. Providing feedback to hospital doctors about prescribing errors; a pilot study. *Pharm World Sci* 2007 Jun;29(3):213-20.
- (51) Haw C, Stubbs J. Prescribing errors at a psychiatric hospital. *Pharm Pract* 2003;13(2):64-6.
- (52) Mandal K, Fraser SG. The incidence of prescribing errors in an eye hospital. *BMC Ophthalmology* 2005 Mar 22;5(1):4.
- (53) Olsen S, Neale G, Schwab K, et al. Hospital staff should use more than one method to detect adverse events and potential adverse events: incident reporting, pharmacist surveillance and local real-time record review may all have a place. *Qual Saf Health Care* 2007 Feb;16(1):40-4.
- (54) Ridley SA, Booth SA, Thompson CM. Intensive Care Society's Working Group on Adverse Incidents. Prescription errors in UK critical care units. *Anaesthesia* 2004 Dec;59(12):1193-200.
- (55) Sagripanti M, Dean B, Barber N. An evaluation of the process-related medication risks for elective surgery patients from pre-operative assessment to discharge. *Int J Pharm Pract* 2002;10(3):161-70.
- (56) Stubbs J, Haw C, Taylor D. Prescription errors in psychiatry - a multi-centre study. *J Psychopharmacol* 2006;(4):553-61.
- (57) Webbe D, Dhillon S, Roberts CM. Improving junior doctor prescribing - The positive impact of a pharmacist intervention. *PharmJ* 2007 Feb;278(7437):136-8.
- (58) Wilson DG, McArtney RG, Newcombe RG, et al. Medication errors in paediatric practice: insights from a continuous quality improvement approach. *Eur J Pediatr* 1998 Sep;157(9):769-74.
- (59) Forster AJ, Halil RB, Tierney MG. Pharmacist surveillance of adverse drug events. *Am J Health Syst Pharm* 2004;61(14):1466-72.
- (60) Ho L, Brown GR, Millin B. Characterization of errors detected during central order review. *C J Hosp Pharm* 1992;45(5):193-7.
- (61) Vira T, Colquhoun M, Etchells E. Reconcilable differences: Correcting medication errors at hospital admission and discharge. *Qual Saf Health Care* 2006;15(2):122-6.

- (62) Fijn R, Van den Bemt PM, Chow M, et al. Hospital prescribing errors: epidemiological assessment of predictors. *Br J Clin Pharmacol* 2002 Mar;53(3):326-31.
- (63) Van den Bemt PMLA, Postma MJ, Van Roon EN, et al. Cost-benefit analysis of the detection of prescribing errors by hospital pharmacy staff. *Drug Saf* 2002;25(2):135-43.
- (64) Van Gijssel-Wiersma DG, Van den Bemt PM, Walenbergh-van Veen MC. Influence of computerised medication charts on medication errors in a hospital. *Drug Saf* 2005;28(12):1119-29.
- (65) Aneja S, Bajaj G, Mehendiratta SK. Errors in medication in a pediatric ward. *Indian Pediatr* 1992 Jun;29(6):727-30.
- (66) Pote S, Tiwari P, D'Cruz S. Medication prescribing errors in a public teaching hospital in India: a prospective study. *Pharm Pract* 2007;5(1):17-20.
- (67) Dawson KP, Penna AC, Drummond D, et al. Prescription errors in a children's ward: audit and intervention. *Aust J Hosp Pharm* 1993;23(5):326-8.
- (68) Parke J. Risk analysis of errors in prescribing, dispensing and administering medications within a district hospital. *J Pharm Pract Res* 2006;36(1):21-4.
- (69) Lustig A. Medication error prevention by pharmacists--an Israeli solution. *Pharm World Sci* 2000 Feb;22(1):21-5.
- (70) Oliven A, Michalake I, Zalman D, et al. Prevention of prescription errors by computerized, on-line surveillance of drug order entry. *Int J Med Inf* 2005 Jun;74(5):377-86.
- (71) Baci V, V, Beirevi-Laan M, Bozikov V, Birus M. Prescribing medication errors in hospitalised patients: a prospective study. *Acta Pharmaceutica* 2005 Jun;55(2):157-67.
- (72) Colpaert K, Claus B, Somers A, et al. Impact of computerized physician order entry on medication prescription errors in the intensive care unit: a controlled cross-sectional trial. *Crit care* 2006 Feb;10(1):R21.
- (73) Lepaux DJ, Schmitt E, Dufay E. Fighting medication errors: Results of a study and reflections on causes and ways for prevention. *Int J Risk Saf Med* 2002;15(4/3):203-11.
- (74) Lisby M, Nielsen LP, Mainz J. Errors in the medication process: Frequency, type, and potential clinical consequences. *Int J Qual Health Care* 2005;17(1):15-22.
- (75) Sangtawesin V, Kanjanapattanakul W, Srisan P, et al. Medication errors at Queen Sirikit National Institute of Child Health. *J Med Assoc Thai* 2003 Aug;86(Suppl 3):S570-S575.
- (76) Villegas AC, Lopez Herrera M, Lopez De Heredia I, et al. Medication errors in a neonatal intensive care unit (NICU). *Patient Safety Research Conference* . 2007.
- (77) Dean B, Barber N, Schachter M. What is a prescribing error? *Qual Saf Health Care* 2000 Dec;9(4):232-7.

- (78) NCC MERP Index for categorizing medication errors.
<http://www.nccmerp.org/pdf/indexBW2001-06-12.pdf> . 2007.
- (79) NPSA risk assessment tool for assessing the level of investigation required, and the external reporting requirements to the NPSA, following adverse incidents involving patients.
http://www.npsa.nhs.uk/site/media/documents/537_annex%20f%20npsa%20risk%20assessment%20tool.doc. 2007.
- (80) Nuckols TK, Bell DS, Liu H, et al. Rates and types of events reported to established incident reporting systems in two US hospitals. *Qual Saf Health Care* 2007 Jun;16(3):164-8.
- (81) Thomas EJ, Petersen LA. Measuring errors and adverse events in health care. *J Gen Intern Med* 2003 Jan;18(1):61-7.
- (82) Evans RS, Pestotnik SL, Classen DC, CI, et al. A Computer-Assisted Management Program for Antibiotics and Other Antiinfective Agents. *N Engl J Med* 1998 Jan;338(4):232-8.
- (83) Ash JS, Sittig DF, Poon EG, et al. The extent and importance of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc* 2007 Jul;14(4):415-23.
- (84) Tobaiqy M, McLay J, Ross S. Foundation year 1 doctors and clinical pharmacology and therapeutics teaching. A retrospective view in light of experience. *Br J Clin Pharmacol* 2007 Sep;64(3):363-72.
- (85) Phansalkar S, Hoffman JM, Nebeker JR, et al. Pharmacists versus non-pharmacists in adverse drug event detection: a meta-analysis and systematic review. *Am J Health Syst Pharm* 2007 Apr;64(8):842-9.
- (86) Lesar TS, Briceland LL, Delcours K, et al. Medication prescribing errors in a teaching hospital. *JAMA* 1990 May;263(17):2329-34.
- (87) Schumock GT, Guenette AJ, Keys TV, et al. Discharge medication prescribing errors in a university teaching hospital: pilot study. *Ashp Midyear Clinical Meeting* 1993;28(Dec):P66.

The causes of and factors associated with prescribing errors: Systematic Review

Mary P Tully PhD¹, Darren M Ashcroft PhD¹, Tim Dornan DM PhD², Penny J Lewis PhD¹, David Taylor PhD³, Val Wass FRCGP PhD².

¹School of Pharmacy and Pharmaceutical Sciences, University of Manchester

²Manchester Medical School Education Research Group

³Liverpool Medical School Education Research Group

Correspondence

Dr Mary P Tully
School of Pharmacy & Pharmaceutical Sciences
University of Manchester
Stopford Building
Oxford Rd
Manchester, M13 9PT, UK
Email: mary.tully@manchester.ac.uk
Tel: +44 (0)161 275 4242
Fax: +44 (0)161 275 2416
Word count: 5034

Abstract

Prescribing errors are common, they result in adverse events and harm to patients and it is unclear how best to prevent them because recommendations are more often based on surmised rather than empirically collected data. This systematic review aimed to identify all informative published evidence concerning the causes of and factors associated with prescribing errors in specialist and non-specialist hospitals, collate it, analyse it qualitatively, and synthesise conclusions from it.

Seven electronic databases for the years 1985 to July 2008. The reference lists of all informative studies were searched for additional citations. To be included, a study had to be of handwritten prescriptions for adult or child in-patients and report empirically collected data on the causes of or factors associated with errors. Publications in languages other than English and studies that evaluated errors for only one disease, one route of administration, or one type of prescribing error were excluded.

Seventeen papers reporting 16 studies, selected from 1261 papers identified by the search, were included in the review. Studies from the USA and UK in university-affiliated hospitals predominated (10/16, 62%). The definition of a prescribing error varied widely and the included studies were not homogeneous enough or of a quality that supported quantitative analysis. Causes were grouped according to Reason's model of accident causation into active failures, error-provoking conditions, and latent conditions. The active failure most frequently cited was a mistake due to inadequate knowledge of the drug or the patient. Skills-based slips and memory lapses were also common. Where error-provoking conditions were reported, there was at least one per error, including lack of training or experience, fatigue, stress, high workload for the prescriber and inadequate communication between health-care professionals. Latent conditions included reluctance to question senior colleagues and inadequate provision of training.

Prescribing errors are often multifactorial, with several active failures and error-provoking conditions often acting together to cause them. In the face of such complexity, solutions addressing a single cause are likely to have only limited benefit. Further rigorous study of the causes of error needs to be conducted, seeking potential ways of reducing error. Multifactorial interventions across many parts of the system will likely be required.

358 words

Introduction

It is well recognised, internationally, that many patients suffer morbidity or mortality as a result of their medical treatment [1-3]. Adverse drug events (ADEs) as a result of prescribed medicines make up the greatest proportion of the reasons for this harm [4]. ADEs can prolong hospital stay and increase the risk of mortality [5]. Preventable ADEs due to errors in, for example, prescribing or administration, result in twice that prolonged stay and cost twice as much money [6]. Prescribing errors, independent of whether they cause harm, are common. A recent systematic review found a median prescribing error rate of 7% of medication orders, 52 prescribing errors per 100 admissions and 24 prescribing errors per 1000 patient days [7]. Healthcare policy is thus understandably focusing on ways to reduce prescribing errors and hence this burden of harm [8].

Developing effective ways to reduce error is dependent upon identifying and understanding their causes and the factors associated with them. Identifying the cause of an error is inextricably linked with knowing the intention of the person who committed it [9]. The action performed may have been different to that originally intended (for example, writing temazepam instead of tamoxifen because of a distraction at the time) or may have been that intended but actually wrong (for example, not decreasing a dose in renal failure because of lack of knowledge that it was necessary). However, many published studies on prescribing errors have used professional opinions of the researchers to surmise the reasons why the errors occurred [10] rather than using empirically collected data from the prescribers. The factors associated with prescribing errors (such as type of ward), however, can be gleaned by others from the objective record and therefore do not need to be obtained directly from the person committing the error. The causes of, and factors associated with, prescribing errors have not hitherto been reviewed systematically. Therefore, there is a need to examine the literature critically and to identify the causes of errors, based on a firm foundation of actual data.

The aim of this review was to identify systematically all informative, published evidence concerning the cause of and factors associated with prescribing errors in specialist and non-specialist hospitals, collate it, analyse it, and synthesise conclusions from it.

Identification and selection of studies

Studies that reported on the causes of and/or factors associated with prescribing errors in handwritten prescriptions, written by doctors for adult and/or child hospital inpatients, were sought. Studies reporting errors specifically due to lack of knowledge, workload or stress were explicitly sought, as there was believed to be a body of literature looking at prescribing errors in relation to these factors. Studies reporting medication errors more broadly were only included in the review if they described the causes of or factors associated with prescribing errors in sufficient specific detail to allow their extraction and analysis.

Studies were identified by searching the following electronic data bases for the years 1985 to July 2008: MEDLINE and MEDLINE In-process and other Non-Indexed

Citations, EMBASE, CINAHL, ASSIA, PsycInfo, Social Science Citation Index and International Pharmaceutical Abstracts. Search terms included: error(s); medication error(s); near miss(es); preventable adverse event(s); prescription(s); prescribe; medication order(s); cause(s); causality; causalities; reason(s); risk factor(s); predictor(s); association; knowledge; stress; workload; work hours; tired(ness); sleepiness; fatigue; exhaustion; active failure; slip(s); lapse(s); mistake(s) inpatient(s); hospital(s) and hospitalization. The reference lists of all included studies were hand searched for additional studies.

We defined cause as ‘reasons reported to the researchers by the prescriber, in structured or unstructured interviews, as being wholly or partially responsible for a specific prescribing error’. We defined factors associated with errors as ‘variables that were linked with the prevalence of specific prescribing errors by the researchers’. Studies were only included when data concerning causes and associated factors were collected empirically; studies where causality or associated factors were surmised (for example, based on professional experience of the data collector) were excluded.

All research designs were included. Studies were not excluded due to methodological quality, but comments are given on the limitations of the study methods and therefore the confidence that could be placed on their findings. Conference abstracts were excluded because they would not contain sufficiently detailed information about causes or contributory factors. Non-English language publications were excluded because there was insufficient time and resource to translate them.

Data extraction and analysis

A data extraction form was used to extract the following information: year and country, study period, hospital setting, methods (including type of study, sampling and review processes, profession of data collector, means of detecting error, causes and associated factors), definitions used, the causes and/or associated factors, and any other relevant information captured by the study. Two reviewers extracted relevant data from each study independently and resolved any differences through discussion. If they could not achieve consensus, a third reviewer arbitrated. Data were entered into an Excel spreadsheet for ease of handling and analysis.

The studies retrieved by the search were extremely heterogeneous. Reason’s model of accident causation [9] was used to categorise and present the data as it has become one of the most commonly used theoretical models when considering medical error. The data were therefore categorised, with increasing proximity to the erroneous event, as latent conditions (such as organisation processes), error-provoking conditions (such as environmental or individual factors that affected performance at the time of the error) and active failures (errors due to slips, lapses, mistakes and violations). Slips are errors in performing an intended action, such as meaning to prescribe carbamazepine but instead writing down chlorpromazine. Lapses are errors resulting from a memory failure, such as prescribing a medication that a patient is allergic to despite this being known. Mistakes are either rule based (misapplying a good rule or choosing a poor one) or knowledge based (such as lacking or overlooking relevant information). Violations are conscious decisions to ignore the accepted rules or procedures of the organisation. We did not present the data numerically (even when

given in the original paper) because, especially for the qualitative studies, this would give a misleading suggestion of quantification where none exists.

Literature Search Findings

The search identified 1261 articles. After initial screening of the abstracts, 1184 did not meet the inclusion criteria. The remaining 79 articles were obtained in full text and assessed for their suitability to be included. Figure 1 describes this process and the reasons for excluding retrieved articles. The main reasons for exclusion were review or editorial articles (n=15), studies with no empirically collected data about causes of or factors associated with errors (n=17), studies not investigating causes of or factors associated with errors (n=12) and studies which included all types of medication error, without differentiation (n=7). Seventeen articles, reporting the findings of 16 unique studies, were included in the review [11-27].

Settings

Most studies had been conducted in the USA (7/16) or UK (3/16). Other countries included; Australia (n=2), Belgium (n=1), Canada (n=1), Croatia (n=1) and The Netherlands (n=1). Over two-thirds had been published after 2000 (11/16). Most (13/16) had been conducted in university-affiliated hospitals. One study had been conducted in two paediatric hospitals [16], one had been conducted in a specialist eye hospital [24] and one did not state its location [25]. The majority of studies (13/16) had been carried out in single hospital sites and three on two sites [15,16,20].

Six studies had been carried out only in adult specialities or wards [12,19-21,25,26]; three included only children's specialties or had been conducted exclusively in paediatric hospitals [11,16,27]. Two (reported in three articles) included prescriptions for both adults and children [17,22,23], and the remaining five did not state the ages of the patients [13-15,18,24]. Five studies (reported in six articles) included prescriptions from all or the vast majority of wards and specialities within the study site(s) [15-18,22-24]. The remainder only provided error data for a single ward [11,12,19,21,25], a limited number of specialties [14,17,19,20,26,27] or a single group of doctors [13].

Study Design

Seven studies [11,13,14,19-21,25] reported data on the causes of prescribing errors (Table 1) and nine studies (reported in ten articles) [12,15-18,22-24,26,27] reported data on the factors associated with prescribing errors (Table 2). One study reported data on both [19].

Most studies (13/16) collected prescribing error data prospectively. Data on causes about specific errors were collected retrospectively, after the identification of the errors. These data had been collected in a variety of ways, using qualitative, semi-structured interviews [13,14,25], structured interviews [20,21] or participant observation of interactions between the doctor and other health care professionals [11,19]. All but one study [21] used open questions to ascertain the cause. Data about causes were usually collected by the authors. Data on associated factors were

collected at the same time as error data for eight studies [12,15,16,18,22-24,26] and retrospectively, using other data sources, in two studies [17,27]. Pharmacists, physicians, and nurses had been the usual data collectors for errors and associated factors.

The majority of studies (11/16) were process based, meaning they reported the findings of healthcare professionals reviewing prescriptions, usually as part of routine work [28]. This type of study does not measure harm as the error is detected and reported to the prescriber before reaching the patient. Only two were outcome based studies [11,25], measuring actual or potential patient harm by reporting adverse drug events [28]. A further three studies were both process and outcome based in that they investigated both incident reports (some of which included actual adverse events) and prescribing errors detected in the prescription itself [19,20,27].

The definition of a prescribing error varied enormously. Most studies provided definitions of their own; five studies [11-14,20] used previously developed definitions by Bates *et al* [29], Dean *et al* [30] or National Co-ordinating Council for Medication Error Reporting and Prevention [31]. Two studies did not state any definitions [15,21] but provided detailed data on the types of prescribing errors included. Two studies used a definition based on actual or potential patient harm [11,20].

Reason's model of accident causation

The authors of five studies used Reason's model of accident causation to describe their findings, either explicitly [13,14,20] or implicitly [11,19]. We categorised the remainder similarly. The data from all seven studies that investigated causes are presented in Table 3, grouped by the stages of Reason's model. Table 4 presents the findings from the studies reporting factors associated with errors. All such associated factors were classified as error-provoking conditions [9] as they were not the unsafe acts themselves.

Active failures

Active failures are the unsafe acts committed by the prescribers in contact with the patient. All errors, therefore, would be expected to be as a result of at least one active failure. Knowledge-based mistakes were the most common failure cited in five studies [11,13,19,20,25]. Prescribers told the researchers that the errors had occurred because they did not know enough either about the drug they were prescribing [13,20,25] or about the patient they were prescribing it for [19,20]. Most of the mistakes reported in these studies related to the dose of the drug prescribed. Examples given included prescribing the wrong dose of anticoagulant [11] or not knowing that a patient's co-morbidity was a contra-indication to the prescribed medicine [20]. Rule-based mistakes, where there was lack of knowledge of a rule (such as how to reduce doses in renal failure), as well as the application of the wrong rule, were reported in one study as being a common active failure [14]. The authors, however, acknowledged that the interviewed doctors may have used this as a "socially acceptable construction of ignorance".

Skill-based slips and memory lapses were described in five studies [11,13,14,19,20] where, for example, prescribers were interrupted during a task or were busy when

they made the error. Such slips were the most common active failure in one study [14]. When directly asked, however, prescribers were not always able to explain exactly why the slips and lapses had occurred [14].

Violations are active choices by the prescriber to ignore the formal or informal policies or guidelines they are expected to adhere to. These were reported in four studies [11,14,19,20]. Examples included prescribing by a medical student that was improperly checked [14] and doctors failing to provide all the information they knew was required on a prescription [11]. In addition, some of the active failures listed above could also be classed as violations of informal rules of practice, such as writing the prescription regardless of the fact that the prescriber did not know about the drug being prescribed.

Error-provoking conditions

Error-provoking conditions are related to the task and the environment at the time when the error occurs. They do not directly cause errors, but are latent risk factors whose presence means an active failure is more likely to cause an error. In the context of prescribing, these error-provoking conditions can be categorised as related to the individual prescriber, their immediate working environment, the broader health-care team, the prescribing task, and patient. Most studies of error-provoking conditions reported a only a single condition per error; four studies reported multiple conditions per error [13,14,21,25]. Coombes *et al* [13] and Patterson *et al* [25] described in detail the interaction between multiple error-provoking conditions in creating the conditions suitable for an active failure to occur.

Individual Prescriber: Since errors due to lack of knowledge about specific drugs were described as one of the commonest active failures, it is unsurprising that lack of training and experience of the prescriber was also reported as an error-provoking condition [13,14,20]. Junior doctors were reported as making more errors in several studies [16,18,27]. These findings are inconclusive, however, because not all studies adjusted the number of errors for overall prescribing rates [18,27]. In one study, junior doctors wrote more prescriptions than their senior colleagues did, but had a similar error rate when not on call [17]. Lesar *et al* [23] did not find a change in the error rates as the house staff training year progressed, although they did not look separately at error rates for each grade of doctor. Wilson, on the other hand, found an increase in error rates when junior doctors started working in a specialist paediatric centre [27].

Doctors described their physical or mental health during interviews, portraying themselves as tired, hungry, thirsty, unwell or with low mood at the time of the error occurrence [13,14]. This was frequently coupled with hurrying and feelings of excessive work load [13,14]. Error rates were found to be highest at the busiest time of the day for prescription writing in one study [23]. The daily prescribing load for individual doctors was a predictor of error rate on univariate analysis in another study, but this disappeared when controlling for other factors in multivariate analysis [15]. Occurrence of errors were significantly associated with prescribing during or immediately following a night on-call, especially for first year doctors [17]. Although the authors suggested that sleep deprivation or fatigue might have been causative

factors, they also recognised that they did not measure the amount of sleep obtained or other confounders such as levels of supervision available.

Working environment: The working environment was not investigated as a factor associated with error occurrence, but was raised during interview studies. Low staffing levels at the time of the error were described in three studies as an error-provoking condition [13,14,20]. Prescribers described their physical environment as being an error-provoking condition, such as the lack of a desk [14] or access to a computer [21]. The latter contributed to lack of access to necessary drug and patient information, although this also occurred with non-computerised records [20].

Health-care team: Issues about prescribing for another doctor's patients [14] and around ambiguity about responsibility for patients [13,14,25], including quality of supervision for junior doctors [13], were raised. Lack of, or poor quality of, communication or documentation was a frequently mentioned error-provoking condition [13,14,19-21,25]. It was the main problem described by Patterson *et al* [25], in a detailed account of the impact of communication problems on a single severe error. Poor or no communication occurred via the telephone [25], paper [14,25] and computers [21]. The negative impact of the medium of communication was discussed in detail by Patterson *et al* when, for example, colleagues on the telephone could not see that the error resulted in an overly large volume of parenteral medication being prepared, which would have been immediately obvious during the equivalent face-to-face communication [25].

Prescribing Task: Non-routine [14,25] and non-standardised [20] prescribing tasks were mentioned as error-provoking conditions. There was a positive association between increasing numbers of drugs prescribed and both errors [12] and preventable adverse events [19]. The layout of the prescription chart was referred to in one study [13], although specific details were not given. The route of administration also increased the odds of an error occurring, especially via eye drops (OR 11.1, 95% CI 4.3 to 28.5) and inhalation (4.1, 2.6 to 6.6), as did the fact that the drug had been prescribed prior to admission to hospital (1.7, 1.3 to 2.3) [15]. Coombes *et al* found different error-provoking conditions associated with errors with new prescriptions compared to rewritten prescriptions (such as re-prescribing medication on admission or discharge) [13]. For errors with new prescriptions, the major factors identified concerned the health care team, the individual prescriber and the patient. For re-prescribing errors, they were the working environment, the task and the duration of experience of the junior doctor.

Patient: Prescribing for patients with acute or complex clinical diseases [13,14], or who were unhelpful or had language difficulties [14], was reported by doctors as being more likely to result in errors. However, patient characteristics were variable in their association with prescribing errors. Fijn *et al* did not find them predictive of errors in either univariate or multivariate analysis [15]. Elsewhere, however, increasing rates of errors were associated with increasing age of adult patients [26] and children [23], and preventable adverse events were associated with increasing age and male patients [19].

The patient's ward was considered as a broad proxy for the type and severity of the patient's medical condition. Children on intensive care units were at greater risk of

errors than those on general wards [16,27]. Medical and surgical wards (particularly orthopaedic [15]) were associated with greater error rates compared to all other types of wards [15,18].

Latent conditions

Latent conditions are the organisational processes that create an environment where error-provoking conditions and active failures are more likely to result in prescribing errors. They were described in five studies, during open questioning of the prescribers, as potential causes of their errors [13,14,20,21,25] and not investigated by any study as factors associated with errors.

A reluctance to question more senior colleagues in the medical team was reported in two studies [14,25] and poor conflict resolution in another [20]. Both Coombes *et al* and Dean *et al* found that some doctors had an attitude that prescribing, especially re-prescribing, was not an important task [13,14]. Drug knowledge, dose selection and prescribing skills were not formally taught [13,14], and there was low self-awareness among doctors that they actually made prescribing errors [14]. A lack of feedback when prescribing errors occurred was found in another study [20], which could potentially contribute to this lack of awareness.

Other latent conditions that were described included lack of integration of clinical and pharmacy computer systems, with logistic problems in transfer of prescribing information [21]. Junior doctors were forced to work long hours because ward rounds were early or late in the day [13] and working rotas were organised so that there was difficulty in accessing specialist staff at the weekend [25].

Discussion

Combining the evidence from the literature about both the causes of and factors associated with the prescribing errors has helped to shed greater light on why and how errors occur than would either alone. The nature of the findings, however, meant that it was impossible to quantify the prevalence of the various causes of prescribing errors. Several studies used qualitative methods [13,14,25], where quantification was obviously not sought. Some limited their investigation to errors caused by particular error-provoking conditions, especially poor communication [21,25]. Other, quantitative, studies of causes were conducted in specialist areas, such as intensive care [11,19] or HIV treatment [21], or only included the subset of prescribing errors that caused actual or potential harm [20]. Similarly, several studies of the factors associated with prescribing errors were also carried in specialist areas, including ophthalmology [24] and intensive care [12,27]. Findings from these studies will not necessarily be generalisable to all hospital wards or to a broader range of errors. Despite this, there was some consistency about the nature of the causes of and factors associated with prescribing errors that were identified by the included studies.

Knowledge-based mistakes, especially about the dose of the drug and the patient's comorbidities, were described as common in most studies, across a broad range of study settings. Slips, lapses and violations were also described, but less often. Lack of training and lack of experience of the prescriber were described as error-provoking

conditions and there were some evidence that working conditions such as busyness or fatigue caused errors and were associated with higher error rates. Poor communication systems between health care professionals were also described as contributing to prescribing errors. There was some evidence that errors were more common in older patients, children, on intensive care wards, and as the number of prescribed drugs per patient increased. Latent conditions were reported in only a few studies and related particularly to the reluctance to discuss errors and lack of formal teaching or feedback within the hospitals.

Our review had a number of limitations. Relevant studies that were not indexed by the databases that we searched (and not cited by studies found) could not be included. Non-English language studies were excluded, because of limitations within our group to translate them. We also excluded abstracts, due to the limited information therein. International work or work in progress may exist, therefore, which could add further to our understanding of the causes or factors associated with prescribing errors.

Many studies were excluded from the review because the data that purported to be about the causes of errors had been surmised by the researchers (Figure 1). Some of the studies provided particularly poor accounts of their methods. Consequently, the task of deciphering whether all or only some of the causality data had been collected empirically was often problematic. Although some errors *could* have been caused by the active failures suggested by the researchers, supposition may not have accurately identified the causes of those *particular* errors. Leape *et al* showed how a single type of medication error (the patient receiving the wrong dose) could have been cause by one of several active failures, including lack of knowledge about the drug, rule violation, faulty dose checking procedures or slips [20]. Although these data included administration, as well as prescribing, errors, they still illustrate the need to collect empirical data about the causes of each error included in a study.

Included studies exhibited various limitations dependant on the methodological approach that they took. Studies which utilised observational techniques were open to the Hawthorne effect [11,19] and doctors may have improved or altered their prescribing if they were aware that they were being observed. Those studies which used interviews could also be affected by social desirability bias and doctors may have responded to questioning in a way that they perceived as being socially acceptable [14], especially when asked about potential violations. No study examined all the possible causes in a large number of errors, so it was not possible to gauge relative importance. The potential for confounding between some error-producing conditions (such as number of drugs prescribed and severity of illness) was examined in only one study [15].

Active failures due to lack of knowledge, especially regarding appropriate doses to prescribe, were very commonly described in the included studies. We have previously reported that the most prevalent type of prescribing error described in the literature was in the dose [7], so this could explain this finding. Clinical pharmacologists have expressed concerns that newly graduated doctors have received inadequate undergraduate training on prescribing [32,33] and recommend additional education in clinical pharmacology and therapeutics. New graduates themselves report feeling unprepared when they begin prescribing [34-36]. Not all doctors agree, however, that detailed training in prescribing could be included in the undergraduate

curriculum [37]. Reasons include regional variations in the specific drugs recommended in hospital formularies. Basic principles of safe prescribing could thus be taught as undergraduates, supplemented by continuing education when practising.

It has been recognised that much of junior doctors' learning occurs in the workplace, in an "apprenticeship" model [38,39]. In one survey, junior doctors reported that they learnt safe prescribing practice by copying other physicians [40]. In contrast to the formal teaching and training that people often equate with learning, informal learning occurs as part of routine work and is often invisible and hence unrecognised [41]. Pharmacists routinely discuss and clarify errant prescriptions with doctors [42], a potentially powerful educational opportunity which may go unnoticed.

Doctors were not always aware that they had actually made prescribing errors until they were pointed out to them [14]. Elsewhere, it was found that a third of intensive care staff did not acknowledge that they actually made errors [43]. Learning from prescribing errors that doctors neither know nor acknowledge that they make is impossible. A pilot study has shown it to be feasible to feedback information about prescribing errors formally to medical teams to improve this, although unfortunately not to individual prescribers [44]. Advances in training in safe prescribing have been proposed for both medical students [45-47] and junior doctors [48,49]. The impact of these interventions on the reduction of prescribing errors, however, has not been investigated. Information technology, such as electronic prescribing (e-prescribing) has been shown to reduce prescribing errors, including dosage errors [50].

Although the lack of undergraduate clinical pharmacology tuition has been proposed, by clinical pharmacologists, as the 'likely' cause of increasing patient morbidity due to prescribing errors [33], there were many other causes reported in these studies which cast doubt on this suggestion. Tiredness, work overload and stress were all cited in multiple articles as error-provoking conditions. These were described by the doctors in one study as being more likely to contribute to an error than was lack of knowledge [40].

Although frequently cited in these studies as an error-provoking condition, the evidence that fatigue has a causal link with clinical performance is mostly based on simulation or proxies [51,52]. No correlation has also been found between proxies for fatigue such as work hours or shift length and either medication errors [53,54] or adverse events [55]. Nonetheless, other hazardous industries, such as aviation, do not tolerate shifts of 24-36 hours that have been (and perhaps still are [54]) common in medicine [51]. Limitations to doctors' hours of work have taken place in both the USA and the UK over the past decade, implemented by the Accreditation Council of Graduate Medical Education and the European Working Time Directive, although the former's impact on working hours in the USA (and potentially patient safety) may not be great [54].

It has been suggested that fatigue may make stress more difficult to cope with [56]. The latter has also been reported as an error-provoking condition for prescribing errors [13,14] and for medication errors more generally [57]. Prescribers who are stressed and burnt out, unlike those suffering from depression, have not been shown to commit more medication errors than their colleagues who do not [58]. In comparison to pilots, doctors may be worse at recognising the potential impact that

stress could have on their performance [43]. It has been suggested that healthcare learns from the experience of aviation, where pilots have been taught how to recognise and address performance limiters such as stress and fatigue [59]. Implementation of one such method, crew resource management training, has been shown to improve stress recognition in an obstetrics unit [60].

The way in which employees' shared attitudes, beliefs and values impact on how they perceive and act on patient safety issues has been called the 'safety culture' of the organisation [61]. Two important aspects of that safety culture are how employees communicate about safety issues and the provision of staff education and training [61,62]. Latent conditions were described in several included studies, where junior doctors did not question potential errors by senior doctors because of potentially negative consequences [14,25] and where they received no formal postgraduate prescribing training [13,14]. 'Shooting the messenger' and denial of the problem are two of the Seven Deadly Sins suggested by the WHO in recognising and addressing patient safety [63]. The Manchester Patient Safety Assessment Framework (MaPSaF), a typological qualitative tool to assess patient safety culture in the UK, would categorise such behaviour as being part of a 'pathological' safety culture, warranting reflection and action at an organisational level [62].

There was clear evidence from several studies [13-15,21,25] that single prescribing errors can result from the interaction of multiple error-provoking conditions. Other authors stated that they had chosen the most important error-provoking condition, whilst recognising that there could be more than one [20]. An in-depth analysis of a single, serious error clearly highlighted the intricate ways in which several error-provoking conditions (in this case, those concerning communication, education and supervision) could combine to cause an error [25]. Even the ward the patient was on when the error occurred could represent more than one, inter-related, error-provoking conditions; it could be a descriptor of the severity of illness of the patient (such as an intensive care unit or minor surgery unit), the speciality of the prescriber (intensivist or surgeon) or the different workload intensity in the two units. This finding is not unique to prescribing errors. Multiple error-provoking conditions have been attributed to causing medication errors [57] and medical errors [64].

Conclusion

This systematic review shows, from a small number of empirical studies, that prescribing errors have potentially multiple causes and error-provoking conditions, often acting together. Prescribers could benefit from learning both technical skills (such as the application of domain knowledge to individual diseases and drugs) and non-technical skills (such as how to address stress or improve intra- and inter-professional communication).

The complexity of prescribing error causation, however, means that simplistic solutions or quick fixes, which address a single cause, are likely to have only limited benefit. They would also not deal with the interconnectedness of the causation system. For example, changing to a shift pattern for doctors' hours to reduce fatigue-mediated errors could possibly increase errors predicated by poor communication between day and night teams. Existing complex solutions have been shown to address the problem only partially. E-prescribing systems, whilst reducing many types of prescribing

errors, can give rise to new types of error, for example, in the process of entering and retrieving information [46,47] and are not a panacea for reducing all prescribing error. Multiple barriers probably need to be put in place, to help prevent, or minimise the impact of, errors that make it defences earlier in the causal chain. Further rigorous study of the multifactorial nature of error causation needs to be conducted, especially focusing on how error reduction methods might work. It is likely that multifactorial interventions and multiple defences across many parts of the system will be required to address this problem.

Acknowledgements

We thank the members of our Expert Reference Group – Graham Buckley, Gary Cook, Dianne Parker, Lesley Pugsley, and Mike Scott - for their helpful comments on our interim analysis.

This study was commissioned by the General Medical Council to contribute to the evidence base informing policy developments. It is part of a programme of work to explore the prevalence and causes of prescribing errors made by first year doctors, concentrating on the interplay between doctors' educational backgrounds and factors in the practice environment.

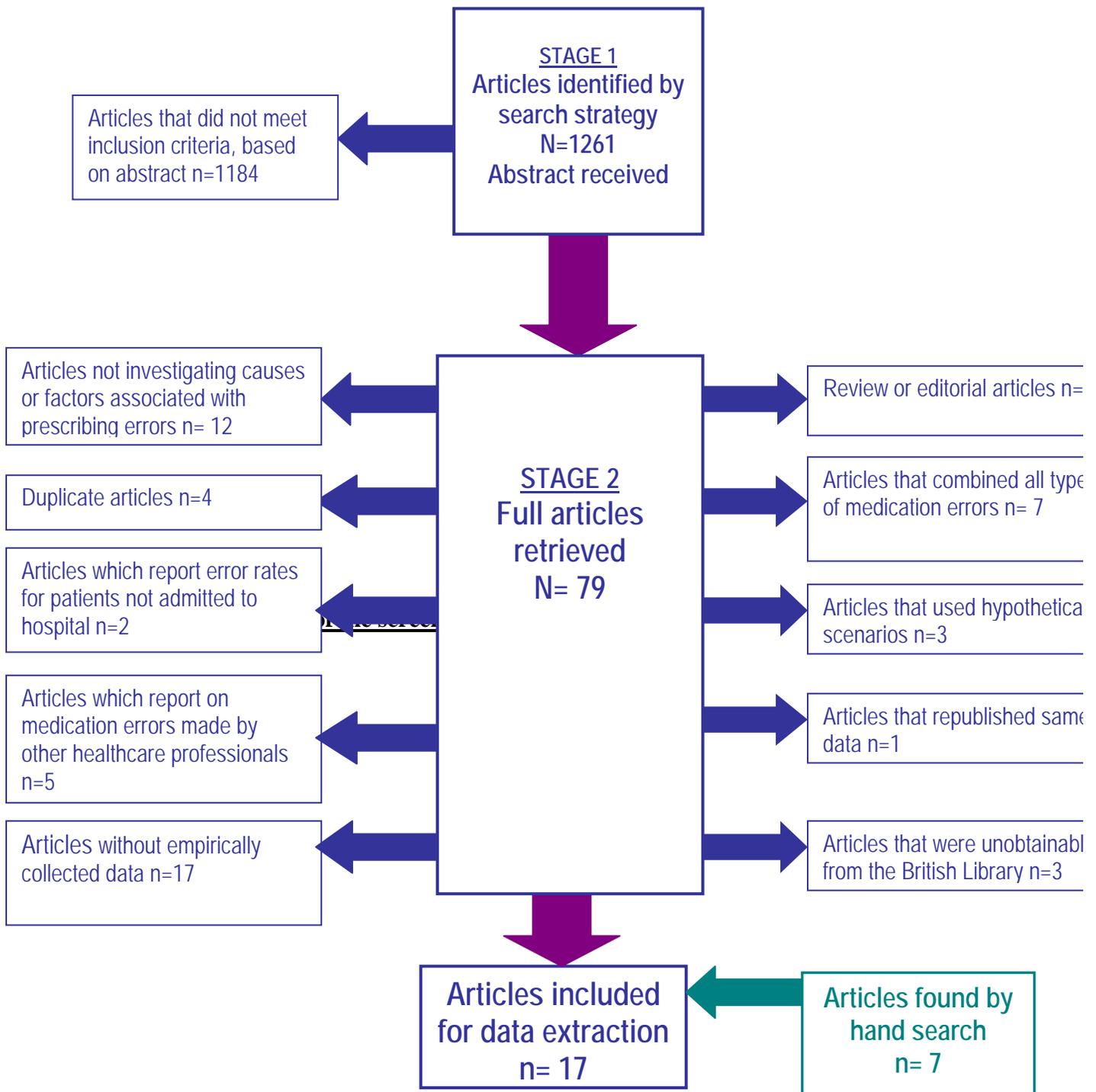


Table 1: Studies reporting on the causes of prescribing errors

First Author	Country	Study sites	Setting	Study period	Adults/ children	Error data		Method of identification of error	Methods for collection of causes data	Who collected data	
						Type of study	Type of data collection			Errors	Causes data
Buckley <i>et al</i> (2007) [11]	USA	Teaching hospital (n=1)	ICU	5 months	C	P	Outcome based	Observations when following one nurse around for entire shift	Observation	Pharmacists	Pharmacists
Coombes <i>et al</i> (2008) [13]	Australia	Teaching hospital (n=1)	NS	5 months	NS	P	Process based	NS	Semi-structured qualitative interviews, discussion with pharmacist, review of medication chart and medical records	NS	Researchers
Dean <i>et al</i> (2002) [14]	UK	Teaching hospital (n=1)	Medical & surgical specialties	8 weeks	NS	P	Process based	Asked pharmacist to inform them of any potentially serious prescribing errors made by doctors for inpatients.	Semi-structured qualitative interviews, questionnaires and review of medical notes 'to obtain additional relevant information	Ward pharmacists	Researchers
*Kopp <i>et al</i> (2006) [19]	USA	Teaching hospital (n=1)	Medical/ surgical ICU	17 days	A	P	Outcome based and process based	Direct observation	Observation of nursing station and therefore all conversations about medicines	Two pharmacy residents specialising in critical care	Two pharmacy residents specialising in critical care
Leape <i>et al</i> (1995) [20]	USA	Teaching hospital (n=2)	ICU (n=5) & general medical units (n=6)	6 months	A	P	Outcome based and process based	Voluntary reports & review of medical records	Interviews of all parties with knowledge of the incident using structured form.	Trained nurse investigators	Peer case investigator.

First Author	Country	Study sites	Setting	Study period	Adults/ children	Error data		Method of identification of error	Methods for collection of causes data	Who collected data	
						Type of study	Type of data collection			Errors	Causes data
Lederman & Parkes (2005) [21]	Australia	Teaching hospital (n=1)	HIV ward	3 weeks	A	P	Process based	Observation of pharmacist doing rounds	Structured interviews	Pharmacists	Researchers
Patterson <i>et al</i> (2004) [25]	USA	NS	oncology patient	NS	A	R	Outcome based	Detected by doctor as part of usual work	Qualitative interviews with 5 people using the critical decision method	NA	Researchers

* This study by Kopp *et al* appears in both tables due to having both causality data and data relating to factors associated with errors.

KEY

A = Adults
C = Children
NS = Not stated
P = Prospective
R = Retrospective

Table 2: Studies reporting on factors associated with prescribing errors

First Author	Country	Study sites	Setting	Study period	Adults/ children	Error data		Method of identification of errors	Factors associated with prescribing errors		Who collected data	
						Type of study	Type of data collection		Type of study	Describe method	Errors	Factors associated with errors
Colpaert <i>et al</i> (2006) [12]	Belgium	Teaching hospital (n=1)	ICU	5 weeks	A	P	Process based	Analysis of every medication order of randomly selected patients	P	Correlations between patient characteristics, number of drug prescriptions and the number of medication prescribing errors	Clinical pharmacist	Clinical pharmacist
Fijn <i>et al</i> (2002) [15]	NL	Teaching hospital (n=2)	All wards	2 weeks	NS	R	Process based	NS	P&R	A retrospective explorative case-control study was performed. Random samples of prescriptions with one or multiple errors were analysed for associated factors	NS	NS
Folli <i>et al</i> (1987) [16]	USA	Children's hospital (n=2)	All wards	6 months	C	P	Process based	Usual screening of prescriptions in pharmacy	P	Data collected at same time as errors data. Conducted statistical comparisons	Pharmacists	Pharmacists
Hendey <i>et al</i> (2005) [17]	USA	Teaching hospital (n=1)	Doctors in adult medical/ surgical wards & critical care areas	1 month	A&C	R	Process based	Detected as part of usual screening by pharmacists	R	Performed a subgroup analysis to determine error rates based on time of day, level of training and acuity level of the unit where the order was written	Pharmacists & two research assistants	Two research assistants
Ho <i>et al</i> (1992) [18]	Canada	Teaching hospital (n=1)	All wards	25 weeks	NS	P	Process based	Detected as part of usual screening by pharmacists	P	By recording of details of the prescriber and circumstances of the error when detected by pharmacist	Dispensary pharmacists	Dispensary pharmacists

First Author	Country	Study sites	Setting	Study period	Adults/ children	Error data		Method of identification of errors	Factors associated with prescribing errors		Who collected data	
						Type of study	Type of data collection		Type of study	Describe method	Errors	Factors associated with errors
Kopp <i>et al</i> 2006 [19]	USA	Teaching hospital (n=1)	Medical/ surgical ICU	17 days	A	P	Outcome based and process based	Direct observation	P	Observation of nursing station and therefore all conversations about medicines	Two pharmacy residents specialising in critical care	Two pharmacy residents specialising in critical care
Lesar <i>et al</i> (1997) [23] & Lesar <i>et al</i> (1997) [22]	USA	Teaching hospital (n=2)	All wards	9 years & 1 year	A&C	P	Process based	Detected as part of usual screening by pharmacists & patient record review	P	Data collected from prescriptions, notes & other factors assigned by researchers during review. The statistical significance of group differences in error rates was determined	Pharmacists	The researchers and pharmacists
Mandal <i>et al</i> (2005) [24]	UK	Specialist eye hospital (n=1)	All wards	1 month	NS	P	Process based	Detected as part of usual screening by pharmacists	P	Non-statistical comparison	Three dispensing pharmacists	Three dispensing pharmacists
Vrca <i>et al</i> (2005) [26]	Croatia	Teaching hospital (n=1)	Different wards of the Clinic of Internal Medicine	25 weeks	A	P	Process based	Medical record analysis	P	Non-statistical comparison	A pharmacist and physician evaluated the medication records	A pharmacist and physician evaluated the medication records
Wilson <i>et al</i> (1998) [27]	UK	Teaching hospital (n=2)	Paediatric cardiac ward (PCW) & 4 bed paediatric cardiac ICU	2 years	C	P	Outcome based & process based	Adverse incident reporting scheme	R	Contrasts between year 1 & year 2, & between PCICU and PCW, were reported in turn as rate ratios, relative to counts of admissions, inpatient days and clinical events	Study's authors collected incident reports made by pharmacists, doctors & nurses	Errors were documented by nurses, pharmacists & doctors using standardised incident report forms. Analysis conducted by researchers.

KEY

A = Adults
C = Children
NS = Not stated

Table 3. Main findings of studies reporting causes of prescribing errors, grouped by stages of Reason’s model of accident causation

First Author	Country	Setting	Active failures (individual unsafe acts)	Error –provoking conditions (task & environment)	Latent conditions (organisational processes)
Buckley <i>et al</i> (2007) [11]	USA	ICU	<i>Knowledge-based mistakes</i> : lack of drug knowledge <i>Violations</i> <i>Slips and lapses</i>		
Coombes <i>et al</i> (2008) [13]	Australia	NS	<i>Knowledge based mistakes</i> <i>Slips</i>	Median of 4 (2-5) per error: <i>Individual prescriber</i> : Hungry, thirsty, tired, Low morale or distracted, Inadequate knowledge, skill, experience, training <i>Working environment</i> : Staffing levels inadequate/unfamiliar with patient, workload – high workload, long hours, pressure <i>Health-care team</i> : Communication problems, remote unclear or lack of supervision, trust or assume that senior checks, decision by senior, detail by junior, weighing risks and benefits, responsibility too great <i>Prescribing task</i> : Medical chart layout or location, ambiguous or unavailable guidelines <i>Patient</i> : Complex problem, acute problem, communication difficulties	Low importance attached to Re-prescribing tasks Simultaneous multiple prescribing tasks Perception of prescribing as a chore Lack of training in drug knowledge and prescribing skills Long hours scheduled Staffing numbers Need to admit specialist patients out of hours
Dean <i>et al</i> (2002) [14]	UK	Medical & surgical specialties	<i>Skill-based slips/lapses</i> : busy or interrupted during routine tasks <i>Rule based mistakes</i> : Absence of knowledge of a relevant rule; Application of the wrong rule <i>Violations</i>	182 cited about 44 errors: <i>Individual prescriber</i> : Skills and knowledge, including training, knowledge and experience and calculations; physical health (tired, hungry or unwell); mental health (low morale) <i>Working environment</i> : Staffing including inadequate, new or locum staff and dealing with other’s patient; heavy workload; physical environment <i>Health-care team</i> : Responsibility; communication e.g. inability to read hand writing, absence of documentation; supervision <i>Prescribing task</i> : Not routine, protocols <i>Patient</i> : Complex clinical disease, unhelpful, language and communication problems	Attitude: prescribing not considered important; Don’t learn about drug doses at medical school; transcription is not prescribing; low self awareness that make errors Culture within team: lack of questioning.
Kopp <i>et al</i> (2006) [19]	USA	Medical/ surgical ICU	<i>Knowledge-based mistakes</i> : lack of drug knowledge, lack of patient information <i>Rule violations</i> : Inadequate monitoring <i>Slips and memory lapses</i>	<i>Health-care team</i> : Faulty interaction with other services	

First Author	Country	Setting	Active failures (individual unsafe acts)	Error –provoking conditions (task & environment)	Latent conditions (organisational processes)
Leape <i>et al</i> (1995) [20]	USA	ICU (n=5) & general medical units (n=6)	<i>Knowledge-based mistakes:</i> lack of knowledge of drug, interactions & doses; lack of information about the patient <i>Rule violations:</i> inadequate monitoring <i>Slips and memory lapses</i>	1 cited per error: <i>Individual prescriber:</i> poor knowledge dissemination <i>Working environment:</i> poor staff and work assignments <i>Prescribing task:</i> lack of standardisation of doses, frequencies and other procedures	Poor allergy defence systems Lack of feedback systems Poor conflict resolution
Lederman & Parkes (2005) [21]	Australia	HIV ward		1 cited for 31 errors & 2 cited for 7 errors <i>Working environment:</i> lack of access to drug information, lack of access to patient information, patient related knowledge not delivered efficiently, slow access to information, lack of access to workstations to find information	Pharmacy systems separate from clinical services. Logistical problems with knowledge transfer in prescribing. Difficulties in storing data.
Patterson <i>et al</i> (2004) [25]	USA	Oncology patient	<i>Knowledge based mistakes</i> <i>Violation:</i> not following chemotherapy policy	All cited for 1 error: <i>Health-care team:</i> Failure to communicate intents/plans behind orders; unwarranted shifts in planning at staff changeover; not rechecking after query 'are you sure'; responsibility for patient care ambiguously distributed <i>Working environment:</i> communication quality negatively influenced by medium used	Difficult to access specialised expertise (at weekend). Reluctance to question people with greater authority.

Table 4: Main findings of studies that explore factors associated with prescribing errors

First Author	Setting	Error –provoking conditions (task & environment)
Colpaert <i>et al</i> (2006) [12]	ICU	<i>Prescribing task:</i> A trend toward more prescription errors with increasing number of drug orders per patient. ($R^2 = 0.431$)
Coombes <i>et al</i> (2008) [13]	NS	<i>Prescribing task:</i> Errors with new prescriptions, median of 5 different factors mentioned; Errors with re-prescribing, median of 3 different factors mentioned
Fijn <i>et al</i> (2002) [15]	All wards	<i>Prescribing task:</i> Univariate analysis: the number of drugs prescribed daily per prescriber, and the weekday of prescribing predictors of prescribing errors. Disappeared after multivariable analysis; Multivariate analysis: preadmission drugs (Odds ratio 1.7, 95% CI 1.3 to 2.3) <i>Patient:</i> Multivariate analysis: Individual patient characteristics were not associated with errors; Multivariate analysis: medical speciality (e.g. orthopaedic surgery OR 3.6, CI 2.1 to 5.4), dosage form (e.g. eye preparations OR 11.1, CI 4.3 to 28.5), therapeutic area (e.g. cancer therapy OR 2.6, CI 1.0 to 6.5)
Folli <i>et al</i> (1987) [16]	All wards	<i>Individual prescriber:</i> The frequency of errant medication orders declined as physicians training status increased ($P < 0.001$) <i>Patient:</i> Error rate per 100 patient days was greater for paediatric ICU patients: 3.26 vs. 1.52 per 100 patient days ($P < 0.001$); Potentially lethal errors greatest in the paediatric ICU: 0.29 vs. 0.09 per 100 patient days ($P < 0.001$)
Hendey <i>et al</i> (2005) [17]	Doctors in adult medical/surgical wards & critical care areas	<i>Individual prescriber:</i> Increased error rate for overnight and post-call orders in comparison to off-call physicians: 2.7% vs. 1.90% (OR 1.44, CI 1.06 to 1.95); Postgraduate year ones had a significantly higher overnight error rate compared with their off-call rate: 4.23% vs. 1.90%; Postgraduate year ones had a similar error rate to post grads year five when off-call but rate was significantly higher overnight: 4.23% vs. 0.52% <i>Patient:</i> Errors rates were significantly higher on the medical/surgical wards during the overnight and post-call ($P = 0.005$). In the critical care area the overnight and post-call error rates were significantly lower than the off-call periods. .
Ho <i>et al</i> (1992) [18]	All wards	<i>Individual prescriber:</i> Error rates associated with experience of doctors: No. errors detected = 1330; Resident physicians: 479 (36%), Interns: 355 (27%), Staff physicians: 350 (26%), Medical student interns: 146 (11%) <i>Patient:</i> Wards associated with most errors: Emergency unit: 11.4 per 1000 orders, Medical teaching wards: 8.7 per 1000 orders, Surgical wards: 8 per 1000 orders, Renal ward: 6.6 per 1000 orders, Geriatric/rehab: 5.7 per 1000 orders, Palliative care: 5.2 per 1000 orders
Kopp <i>et al</i> 2006 [19]	Medical/ surgical ICU	Variables associated with preventable adverse drug events: <i>Prescribing task:</i> Increasing number of medicines: IRR 1.64 (1.16-2.32) per medicine <i>Patient:</i> Male gender of patient: incident rate ratio (IRR) 1.7 (1.1-2.62) Increasing patient age: IRR 1.01 (1.00-1.02) per year
Lesar <i>et al</i> (1997) [23] & Lesar <i>et al</i> (1997) [22]	All wards	<i>Individual prescriber:</i> Total error rates per 1000 medication orders were highest between 8am and noon and lowest between midnight and 4am: 2.9 per 1000 medication orders and 1.8 per 1000 medication orders ($P < 0.001$) respectively. Serious error rates were highest between 8am and noon and 4pm and 8pm and lowest between midnight and 4am: 0.6 per 1000 medication orders and 0.3 per 1000 medication orders ($P < 0.001$) respectively. The error rate per 1000 orders varied significantly by month ($p < 0.001$) with the highest error rate occurring in November and the lowest in February. No significant trend in error rate occurred as the July to June house staff training year progressed. <i>Patient:</i> Errors greatest for paediatric service and emergency: 5.93 per 1000 medication orders and 5.5 per 1000 medication orders ($P < 0.001$) respectively.
Mandal <i>et al</i> (2005) [24]	Eye hospital	<i>Individual prescriber:</i> No statistical comparison between errors made by different grades of doctor. All drug related errors (defined as incorrect drug dose or timing or incorrect route of administration) were by junior doctors (n=15, 100%)

First Author	Setting	Error –provoking conditions (task & environment)
Vrca <i>et al</i> (2005) [26]	Different wards of the Clinic of Internal Medicine	<i>Patient:</i> Errors increased with increasing age: Age group 41-50: 1.94% of prescriptions had errors, 51-60: 15.5%, 61-70: 16.4%, 71-78: 24.6%
Wilson <i>et al</i> (1998) [27]	Paediatric cardiac ward (PCW) & 4 bed paediatric cardiac ICU	<i>Individual prescriber:</i> Prescription errors doubled when new doctors joined the rotation: Ratio for new doctors versus no new doctors was 173 to 112 (1.55) <i>Patient:</i> Errors more than 7 times likely to occur in the intensive care setting.

* Data recalculated.

References

1. Kohn, L., Corrigan, J., Donaldson, M. To err is human: building a safer health system. Washington, DC: National Academy Press; 2000.
2. Chief Medical Officer. An organisation with a memory. Report of an expert group on learning from adverse events in the NHS. London: Stationary Office; 2000.
3. Australian Council for Safety and Quality in Health Care. Patient Safety: towards sustainable improvement. Fourth report to the Australian Health Ministers' Conference. 2003. Canberra, Australian Council for Safety and Quality in Health Care.
4. Leape, L. L., Brennan, T. A., 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(6):377-384.
5. Classen, D. C., Pestotnik, S. L., Evans, R. S. et al. Adverse drug events in hospitalized patients. Excess length of stay, extra costs, and attributable mortality. *JAMA* 1997;277:301-306.
6. Bates, D. W., Spell, N., Cullen, D. J. et al. The costs of adverse drug events in hospitalized patients. *JAMA* 1997;277:307-311.
7. Lewis, P., Dornan, T., Taylor, D. et al. Systematic review of the prevalence, incidence and nature of prescribing errors in hospital inpatients. *Drug Saf.* 2009;in press.
8. Department of Health. Building a Safer NHS for Patients – Improving Medication Safety. 2004. London, The Stationary Office.
9. Reason, J. Human error. Cambridge: University of Cambridge; 1990.
10. Neale, G., Woloshynowych, M., Vincent, C. Exploring the causes of adverse events in NHS hospital practice. *J R. Soc Med* 2001;94(7):322-330.
11. Buckley, M. S., Erstad, B. L., Kopp, B. J. et al. Direct observation approach for detecting medication errors and adverse drug events in a pediatric intensive care unit. *Pediatric Critical Care Medicine* 2007;8(2):145-152.
12. Colpaert, K., Claus, B., Somers, A. et al. Impact of computerized physician order entry on medication prescription errors in the intensive care unit: A controlled cross-sectional trial. *Critical Care* 2006;10(1):R21 (doi 10.1186/cc3983).
13. Coombes, I. D., Stowasser, D. A., Coombes, J. A. et al. Why do interns make prescribing errors? A qualitative study. *Med. J. Aust.* 2008;188(2):89-94.

14. Dean, B., Schachter, M., Vincent, C. et al. Causes of prescribing errors in hospital inpatients - a prospective study. *Lancet* 2002;359:1373-1378.
15. Fijn, R., Van den Bemt, P. M., Chow, M. et al. Hospital prescribing errors: epidemiological assessment of predictors. *Brit. J. Clin. Pharmacol.* 2002;53(3):326-331.
16. Folli, H. L., Poole, R. L., Benitz, W. E. Medication error prevention by clinical pharmacists in two children's hospitals. *Pediatrics* 1987;79:718-722.
17. Hendey, G. W., Barth, B. E., Soliz, T. Overnight and postcall errors in medication orders. *Academic Emergency Medicine* 2005;12(7):629-634.
18. Ho, L., Brown, G. R., Millin, B. Characterization of errors detected during central order review. *Canadian Journal of Hospital Pharmacy* 1992;45(5):193-197.
19. Kopp, B. J., Erstad, B. L., Allen, M. E. et al. Medication errors and adverse drug events in an intensive care unit: Direct observation approach for detection. *Critical Care Medicine* 2006;34(2):415-425.
20. Leape, L. L., Bates, D. W., Cullen, D. J. et al. Systems analysis of adverse drug events. ADE Prevention Study Group. *JAMA* 1995;274(1):35-43.
21. Lederman, R. M., Parkes, C. Systems failure in hospitals - using Reason's model to predict problems in a prescribing information system. *Journal of Medical Systems* 2005;29(1):33-43.
22. Lesar, T. S., Briceland, L., Stein, D. S. Factors related to errors in medication prescribing. *Jama-Journal of the American Medical Association* 1997;277(4):312-317.
23. Lesar, T. S., Lomaestro, B. M., Pohl, H. Medication-prescribing errors in a teaching hospital. A 9-year experience. *Arch. Intern. Med.* 1997;157:1569-1576.
24. Mandal, K., Fraser, S. G. The incidence of prescribing errors in an eye hospital. *BMC Ophthalmology* 2005;5:4 (doi 10.1186/1474-2415-5-4).
25. Patterson, E. S., Cook, R. I., Woods, D. D. et al. Examining the complexity behind a medication error: Generic patterns in communication. *IEEE Transactions on Systems Man and Cybernetics Part A-Systems and Humans* 2004;34(6):749-756.
26. Vrca, V. B., Becirevic-Lacan, M., Bozиков, V. et al. Prescribing medication errors in hospitalised patients: A prospective study. *Acta Pharmaceutica.* 2005;55(2):157-167.
27. Wilson, D. G., McArtney, R. G., Newcombe, R. G. et al. Medication errors in paediatric practice: insights from a continuous quality improvement approach. *European Journal of Pediatrics* 1998;157(9):769-774.
28. Dean Franklin, B., Vincent, C., Schachter, M. et al. The incidence of prescribing errors in hospital inpatients: an overview of the research methods. *Drug Saf* 2005;28(10):891-900.

29. Bates, D. W., Cullen, D. J., Laird, N. et al. Incidence of adverse drug events and potential adverse drug events. *JAMA* 1995;274:29-34.
30. Dean, B., Barber, N., Schachter, M. What is a prescribing error? *Qual. Health Care* 2000;9:232-237.
31. NCC MERP Index for categorizing medication errors. National Co-ordinating Council for Medication Error Reporting and Prevention 2008 [Accessed 26-9-2008]; Available from: URL: <http://www.nccmerp.org/pdf/indexBW2001-06-12.pdf>
32. Maxwell, S. R., Cascorbi, I., Orme, M. et al. Educating European (junior) doctors for safe prescribing. *Basic Clin. Pharmacol. Toxicol.* 2007;101(6):395-400.
33. Tobaiqy, M., McLay, J., Ross, S. Foundation year 1 doctors and clinical pharmacology and therapeutics teaching. A retrospective view in light of experience. *Br. J. Clin. Pharmacol.* 2007;64(3):363-372.
34. Han, W. H., Maxwell, S. R. Are medical students adequately trained to prescribe at the point of graduation? Views of first year foundation doctors. *Scott. Med. J.* 2006;51(4):27-32.
35. Coombes, I. D., Mitchell, C. A., Stowasser, D. A. Safe medication practice: attitudes of medical students about to begin their intern year. *Med. Educ.* 2008;42(4):427-431.
36. Heaton, A., Webb, D. J., Maxwell, S. R. Undergraduate preparation for prescribing: the views of 2413 UK medical students and recent graduates. *Br. J. Clin. Pharmacol.* 2008;66(1):128-134.
37. Molokwu, C. N., Sandiford, N., Anosike, C. Safe prescribing by junior doctors. *Br. J. Clin. Pharmacol.* 2008;65(4):615-616.
38. Brazil, E., Macnamara, A. F., O'Connor, N. et al. Accident and emergency medicine--still a useful 'apprenticeship'? *Eur. J. Emerg. Med.* 2002;9(3):244-247.
39. Bleakley, A. Pre-registration house officers and ward-based learning: a 'new apprenticeship' model. *Med. Educ.* 2002;36(1):9-15.
40. Garbutt, J. M., Highstein, G., Jeffe, D. B. et al. Safe medication prescribing: Training and experience of medical students and housestaff at a large teaching hospital. *Acad. Med.* 2005;80(6):594-599.
41. Eraut, M. Informal learning in the workplace. *Studies in Continuing Education* 2004;26:247-273.
42. Dean, B., Schachter, M., Vincent, C. et al. Prescribing errors in hospital inpatients: their incidence and clinical significance. *Qual Saf Health Care* 2002;11(4):340-344.

43. Sexton, J. B., Thomas, E. J., Helmreich, R. L. Error, stress, and teamwork in medicine and aviation: cross sectional surveys. *BMJ* 2000;320(7237):745-749.
44. Dean Franklin, B., O'Grady, K., Paschalides, C. et al. Providing feedback to hospital doctors about prescribing errors; a pilot study. *Pharm. World Sci.* 2007;29(3):213-220.
45. Scobie, S. D., Lawson, M., Cavell, G. et al. Meeting the challenge of prescribing and administering medicines safely: structured teaching and assessment for final year medical students. *Med. Educ.* 2003;37(5):434-437.
46. Maxwell, S. R., McQueen, D. S., Ellaway, R. eDrug: a dynamic interactive electronic drug formulary for medical students. *Br. J. Clin. Pharmacol.* 2006;62(6):673-681.
47. Smith, A., Tasioulas, T., Cockayne, N. et al. Construction and evaluation of a web-based interactive prescribing curriculum for senior medical students. *Brit. J. Clin. Pharmacol.* 3-12-2006;62(6):653-659.
48. Gage, S., Roberts, D., Harris, J. et al. Development of an all Wales drug chart, prescription writing standards and e-learning package. *Pharm World Sci.* 2005;27:A21.
49. e-Learning Safe Prescribing. Department of Health 2008 [Accessed 9-10-2008]; Available from: URL: <http://www.e-lfh.org.uk/Projects/Safe-Prescribing.aspx>
50. Ammenwerth, E., Schnell-Inderst, P., Machan, C. et al. The Effect of Electronic Prescribing on Medication Errors and Adverse Drug Events: A Systematic Review. *J. Am. Med. Inform. Assoc.* 2008;15(5):585-600.
51. Gaba, D. M., Howard, S. K. Patient safety: fatigue among clinicians and the safety of patients. *N. Engl. J. Med.* 2002;347(16):1249-1255.
52. Weinger, M. B., Ancoli-Israel, S. Sleep deprivation and clinical performance. *JAMA* 2002;287(8):955-957.
53. Davydov, L., Caliendo, G., Mehl, B. et al. Investigation of correlation between house-staff work hours and prescribing errors. *Am. J Health Syst. Pharm* 2004;61(11):1130-1134.
54. Landrigan, C. P., Fahrenkopf, A. M., Lewin, D. et al. Effects of the accreditation council for graduate medical education duty hour limits on sleep, work hours, and safety. *Pediatrics* 2008;122(2):250-258.
55. Mycyk, M. B., McDaniel, M. R., Fotis, M. A. et al. Hospitalwide adverse drug events before and after limiting weekly work hours of medical residents to 80. *Am. J. Health Syst. Pharm.* 2005;62(15):1592-1595.
56. Firth-Cozens, J., Cording, H. What matters more in patient care? Giving doctors shorter hours of work or a good night's sleep? *Qual Saf Health Care* 2004;13(3):165-166.

57. Nichols, P., Copeland, T. S., Craib, I. A. et al. Learning from error: identifying contributory causes of medication errors in an Australian hospital. *Med. J. Aust.* 2008;188(5):276-279.
58. Fahrenkopf, A. M., Sectish, T. C., Barger, L. K. et al. Rates of medication errors among depressed and burnt out residents: prospective cohort study. *BMJ* 2008;336(7642):488-491.
59. Helmreich, R. L. On error management: lessons from aviation. *BMJ* 2000;320(7237):781-785.
60. Haller, G., Garnerin, P., Morales, M. A. et al. Effect of crew resource management training in a multidisciplinary obstetrical setting. *Int J Qual Health Care* 2008;20(4):254-263.
61. Kirk, S., Marshall, M., Claridge, T. et al. Evaluating safety culture. In: Walshe, K and Boaden, R. *Patient Safety. Research into Practice.* Maidenhead: Open University Press; 2006. 173-184.
62. MaPSaF. National Patient Safety Agency 2008 [Accessed 22-10-2008]; Available from: URL: <http://www.npsa.nhs.uk/nrls/improvingpatientsafety/humanfactors/mapsaf/>
63. Arnaudova, A., Jakubowski, E. Eighth Futures Forum on Governance of Patient Safety. Copenhagen, Denmark: WHO Regional Office for Europe; 2005.
64. Wu, A. W., Folkman, S., McPhee, S. J. et al. Do house officers learn from their mistakes? *JAMA* 1991;265(16):2089-2094.

Appendix C

Pharmacist Name: _____
Date: _____

Prescribing stage:
 A= on admission
 D= during stay
 R= rewriting drug chart
 T=TTA/Discharge Rx
 NK= not known

Hospital name

Ref No.	Prescriber				Foundation year one		Foundation year two		Specialist trainees		Staff grade		Consultant		Pharmacist		Nurse		Not known	
	Ward	Patient Initials	Prescribing stage	Elect Rx ✓	No. of drugs checked	No. of items with Rx error	No. of drugs checked	No. of items with Rx error	No. of drugs checked	No. of items with Rx error	No. of drugs checked	No. of items with Rx error	No. of drugs checked	No. of items with Rx error	No. of drugs checked	No. of items with Rx error	No. of drugs checked	No. of items with Rx error	No. of drugs checked	No. of items with Rx error
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
26																				
27																				
28																				
29																				
30																				

Ref No.

Pharmacist

Ward

Patient ID

Drug involved (name, dose, frequency):

Grade of responder	
Foundation year 1	<input type="checkbox"/>
Foundation year 2	<input type="checkbox"/>
Specialist trainee	<input type="checkbox"/>
Staff grade	<input type="checkbox"/>
Consultant	<input type="checkbox"/>
Pharmacist	<input type="checkbox"/>
Nurse	<input type="checkbox"/>
Not known	<input type="checkbox"/>

Potential severity of error	
Potentially lethal error	<input type="checkbox"/>
Serious error	<input type="checkbox"/>
Significant error	<input type="checkbox"/>
Minor error	<input type="checkbox"/>



Patient details:

Age: _____ Sex: _____	Any other relevant information about the patient:
Indication for drug: _____	_____
Actual patient harm caused: Yes <input type="checkbox"/> No <input type="checkbox"/>	

Description of error:

Brief reason why particular potential severity rating was chosen (if actual patient harm occurred please describe this as well):

Ref No.

Pharmacist

Ward

Patient ID

Drug involved (name, dose, frequency):

Grade of responder	
Foundation year 1	<input type="checkbox"/>
Foundation year 2	<input type="checkbox"/>
Specialist trainee	<input type="checkbox"/>
Staff grade	<input type="checkbox"/>
Consultant	<input type="checkbox"/>
Pharmacist	<input type="checkbox"/>
Nurse	<input type="checkbox"/>
Not known	<input type="checkbox"/>

Potential Severity of error	
Potentially lethal error	<input type="checkbox"/>
Serious error	<input type="checkbox"/>
Significant error	<input type="checkbox"/>
Minor error	<input type="checkbox"/>

Patient details:

Age: _____ Sex: _____	Any other relevant information about the patient:
Indication for drug: _____	_____
Actual patient harm caused: Yes <input type="checkbox"/> No <input type="checkbox"/>	

Description of error:

Brief reason why particular severity rating was chosen (if actual patient harm occurred please describe this as well):

Appendix D

Severity Error Classification Scheme

<p>Potentially lethal error¹</p>	<p>An error is defined as potentially lethal if it could have one or more of the following consequences:</p> <ul style="list-style-type: none"> ▪ The serum level resulting from such a dose is likely to be in the severe toxicity range based on common dosage guidelines, e.g. serum theophylline concentrations greater than 30 micrograms per ml. More than 10 times the dose of chemotherapy agent ▪ The drug being administered has a high potential to cause cardiopulmonary arrest in the dose ordered. ▪ The drug being administered has a high potential to cause a life threatening adverse reaction, such as anaphylaxis, in light of the patient's medical history. ▪ The dose of a potentially life saving drug is too low for a patient having the disease being treated ▪ The dose of a drug with a very low therapeutic index is too high (ten times the normal dose)
<p>Serious error²</p>	<p>An error is defined as serious if it could have one or more of the following results:</p> <ul style="list-style-type: none"> ▪ The route of drug administration ordered is inappropriate, with the potential of causing the patient to suffer a severe toxic reaction. ▪ The dose of the drug prescribed is too low for a patient with serious disease who is in acute distress ▪ The dose of a drug with a low therapeutic index is too high (four to ten times the normal dose) ▪ The dose of the drug would result in serum drug levels in the toxic range, e.g. theophylline levels 20-30 micrograms per mL. ▪ The drug orders could exacerbate the patient's condition, e.g. drug-drug interaction or drug-disease interaction. ▪ The name of the drug is misspelled or illegible creating a risk that the wrong drug might be dispensed including errors in decimal points or units if the error could lead to the dose being given ▪ High dosage (ten times) normal of a drug without a low therapeutic index
<p>Significant error¹</p>	<p>An error is defined as significant if it could have one or more of the following results:</p> <ul style="list-style-type: none"> ▪ The dose of the drug with low therapeutic index is too high (half – four times the normal dose) ▪ The dose of the drug is too low for a patient with the condition being treated ▪ The wrong laboratory studies to monitor a specific side effect of a drug are ordered e.g. CBC and reticulocyte counts are ordered to monitor gentamicin toxicity ▪ The wrong route of administration for the condition being treated is ordered e.g. the inadvertent change from IV to oral therapy for the

	<p>treatment of bacterial</p> <ul style="list-style-type: none"> ▪ meningitis. ▪ Errors ordering fluids are made e.g. specific additives needed for complete therapy are omitted or incompatible fluids are ordered ▪ Errors of omission whereby patient's regular medication is not prescribed either on admission, during a rewrite and on discharge
<p>Minor error ^{2,3,4,5}</p>	<p>An error is defined as minor if it could have one or more of the following results:</p> <ul style="list-style-type: none"> ▪ Duplicate therapy was prescribed without potential for increased adverse effects ▪ The wrong route was ordered without potential for toxic reactions or therapeutic failure ▪ The order lacked specific drug, dose, dosage strength, frequency, route or frequency information ▪ Illegible, ambiguous or non-standard abbreviations ▪ An errant order was written that was unlikely to be carried out given the nature of the drug, dosage forms, route ordered, missing information etc <p>Examples include, simvastatin prescribed in the morning rather than at night. Bisoprolol – two puffs four times a day.</p>

1. Folli HL, Poole RL, Benitz WE, Russo JC. Medication error prevention by clinical pharmacists in two children's hospitals. *Pediatrics* 1987; 79(5):718-722.
2. Lesar TS, Briceland LL, Delcoure K, Parmalee JC, Masta-Gornic V, Pohl H. Medication prescribing errors in a teaching hospital. *JAMA* 1990; 263(17):2329-2334.
3. Lesar TS, Lomaestro BM, Pohl H. Medication-prescribing errors in a teaching hospital. A 9-year experience. *Archives of Internal Medicine* 1997; 157(14):1569-1576.
4. Lesar TS, Briceland L, Stein DS. Factors related to errors in medication prescribing. *JAMA* 1997; 277(4):312-317.
5. Tully MP, Parker D, Buchan I, McElduff P, Heathfield H, et al. Patient safety research programme: medication errors 2: pilot study. 2006.

Appendix E

Interview Schedule

Little is known about the links between prescribing errors and medical education. The purpose of the interview is to explore your experiences of prescribing errors, your opinions on the reasons for these errors and the relationship that these errors had to the undergraduate teaching that you received.

Confidentiality is assured at all times and information analysed or reported from this interview will not enable anyone to recognise you. Patient information is not required; if however, patients are mentioned during interview their details will be immediately removed from all records.

The interview will last approximately half an hour to an hour and the areas to be covered include a few questions about yourself and your background, the particular incidents I asked you to think about and also a few general questions about this topic.

The interview will be taped unless you are opposed to this. The tapes will be kept securely for five years after the study is completed then destroyed.

Do you have any questions before starting the interview?

Part ONE

Background [brief]

Can you tell me a little about yourself?

- Place of medical education
- Which academic quartile in for FY1 application?
- Speciality
- How long in post
- Previous prescribing training & experience, (at medical school, especially in final year and in hospital)
- How this was taught (lectures, tutorials, placement etc)
- Assessments

Part TWO

The prescribing errors [in-depth]

- In the letter I sent to you, I asked if you could make a note of any prescribing errors that you had made. Could you please tell me about these?

- Errors can be anything from what you might perceive to be small 'silly' things to the more serious errors. I am interested in all.

Prompts will be used to obtain more in-depth information regarding the particular error

Prompts

Could you say something more about that?
Can you give a more detailed description of what happened?
You said...what do you mean by that?
Tell me what you are thinking
Why did you hesitate just then?
How did you go about answering that question?

Areas to be covered

- **The nature of the error**
 - The type of error made
 - *Dosing errors; frequency errors; errors in choice of drug such as contraindications, interactions, lack of indication; pharmaceutical errors, omission of information etc.*
 - **The medication involved**
 - *Dose/frequency/formulation*
 - **The condition being treated**
 - *Commonness of condition*
 - *Severity*
 - **Did the error reach the patient?**
 - If so what were the consequences
 - If not how did you find out about the error
- **The situation of the error**
 - **When? (recent)**
 - **Time of day**
 - **How were you feeling at the time – tired, etc if in a rush then why?**
 - **Who else was there at the time**
 - **Type of ward**
 - **How long worked on ward**
 - **Supervision**
 - **General workload**
 - **Stage of patient stay**
 - **Can you describe the patient involved? Please do not mention any names.**
 - *Age/personality/social class/ethnicity*
 - *Doctor-patient relationship/seen patient before/ own patient/on-call*
- **Reasons for making the error**
 - Lack of support, lack of knowledge, lack of communication, lack of information, a lapse or slip in memory

- **Their attitude towards the error**
 - **Has this happened before?**
 - **Has this happened since?**
 - Has this happened to anyone else?
 - **Do you think there was anything that could have prevented the error?**
 - What did the consultant or colleagues think about the situation?
 - **How did the error make you feel?**
 - *Why? /how long for?*
 - **Did it change the way you prescribe?**
 -
- **Coping with the error**
 - Mechanisms and means of coping with complex/difficult prescribing
 - Coping strategies employed

Part THREE

Experiences and attitudes towards basic medical education and errors

How do you feel about the training/teaching that you received at medical school/ trust?
(type e.g. PBL, tutorial)

If poor – why?

If good – why?

What would you want more of?

What would you want less of?

How would you like it taught?

What did you expect when starting as FY1 doctor?

How was the transition between student and FY1 doctor?

Perceived differences between pharmacology and prescribing?

Do you feel that in general prescribing is safe where you are working? (The perceived safety culture of the hospital)

Impact of pharmacists?

What is a prescribing error?

Concluding part

Is there anything else you would like to talk about? Or anything you would like to go back to?

Switch off the tape recorder

I would like to thank you for your time. This interview has been extremely valuable to the research. If desired a copy of the interview transcript can be posted on to you. When the study is completed a summary of the findings will be sent to you if you wish. In the meanwhile please feel free to contact me if you have any questions or other issues would like to discuss

Post interview

A thank you letter is to be posted to the participant.

Interview Schedule

Little is known about the links between prescribing errors and medical education. The purpose of the interview is to understand what is taught at medical school about prescribing. We would like to gain an insight into the content, methods and context of any undergraduate teaching that is carried out in your medical school in the area of prescribing.

Confidentiality is assured at all times and information analysed or reported from this interview will not enable anyone to recognise you.

The interview will last approximately 15-20 minutes. The interview will be taped unless you are opposed to this. The tapes will be kept securely for five years after the study is completed then destroyed.

Do you have any questions before starting the interview?

Part ONE

Background [brief]

Can you tell me a little about yourself?

- Background
- Your role in the medical school
- How long in post

Part TWO

The undergraduate curriculum [in-depth]

- Can you provide a brief description/definition of the medical programme that you provide e.g PBL, intergrated, subject-based, lecture based, PBL supported by lectures and other activities, core plus options, graduate entry etc
- Do you think that your curriculum prepares doctors well for prescribing?
 - What is it in the curriculum that prepares them?
 - Where do you think there are gaps?
 - What would you add?
- Can you describe any elements of the undergraduate course that cover the topic of prescribing?
 - Type of teaching/learning (including mode of teaching i.e. lectures/tutorials)
 - identify overall approach from list below:
 - Distinct course in basic pharmacology

- Integrated learning with system-based modules
 - Mainly opportunistic learning during clinical attachments
 - Mainly self-directed learning through PBL casework/ discussions
- Topics covered (e.g. dosing, indications, contraindications, interactions)
- Length of teaching
- Years of undergraduate study
- Is there any interdisciplinary teaching in the undergraduate course?
- Can you tell me about any assessments that are carried in prescribing skills or assessments that cover this topic?
 - When they take place
 - Type of assessment
- How effective do you think these are?
 - Any means of receiving feedback
- Have you recently changed the curriculum in order to provide more teaching in this area?
 - Why was this done?
 - How was this done?
 - What was taken out?

Concluding part

Is there anything else you would like to talk about? Or anything you would like to go back to?

Switch off the tape recorder

I would like to thank you for your time. This interview has been extremely valuable to the research. If desired a copy of the interview transcript can be posted on to you. When the study is completed a summary of the findings will be sent to you if you wish. In the meanwhile please feel free to contact me if you have any questions or other issues would like to discuss

Post interview

A thank you letter is to be posted to the participant.