

**The prevalence and incidence of prescribing errors:
Systematic Review**

Report to The General Medical Council

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Abstract

Aim

Systematically 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.

Methods

A search strategy was developed and applied to MEDLINE, EMBASE, and International Pharmaceutical Abstracts. The journal Quality and Safety in Health Care was hand searched and the reference lists of all informative studies were searched for additional citations. To be included, a study had to be of handwritten prescriptions for adults or children and contain sufficient data for an error rate to be calculated. 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.

Results

Median error rates (interquartile range) were 7% (2-14%) of medication orders, 52 (8-227) errors per 100 admissions, and 24 (6-212) per 1000 patient days. Most research was in single hospitals in the USA and UK. There were studies of paediatric practice, adult practice, and both together. Prescribing errors were usually intercepted and reported by pharmacists before they caused harm (process errors) although 3% of studies reported adverse drugs events (outcome errors) and 14% of

studies reported both process and outcome errors. Definitions varied widely and were often specific to the study rather than derived from prior consensus or research. Antimicrobials were the class of drug most strongly associated with errors and incorrect dosage was the most common type of error. Lack of use of any standard rating system made it impossible to draw any general conclusions about the severity of errors.

Conclusions

Seven percent of orders, 2% of bed days and 50% of hospital admissions were affected by prescribing errors, highlighting an important threat to patient safety. There was also wide variability in the reported prevalence and incidence of prescribing errors. Whilst that variability must partly reflect the wide range of definitions and ascertainment methods used in the research surveyed, it likely also reflects wide variability in the quality of healthcare. The findings reported here do not clarify the cause of that variability but our forthcoming systematic review of the types and causes of errors may shed some light on the proportion of it that is caused by educationally remediable deficits in physicians' competence.

Abbreviations

A&E	Accident and Emergency
ADE	Adverse drug event
ASHP	American Society of Health-System Pharmacists
BNF	British National Formulary
CoE	Care of the Elderly
CPOE	Computerised Physician Order Entry
ED	Emergency Department
GP	General Practitioner
ICU	Intensive Care Unit
MPE	Medication Prescribing Errors
NCCMERP	National Coordinating Council for Medication Error Reporting and Prevention
NICU	Neonatal Intensive Care Unit
NS	Not stated
PICU	Paediatric Intensive Care Unit
PMR	Patient Medication Records
TPN	Total Parental Nutrition

Introduction

This review is part of a programme of research stimulated by concern that foundation year 1 (FY1) trainees make disproportionate numbers of prescribing errors. The General Medical Council (GMC) wishes to know the prevalence of such errors and the extent to which they reflect weaknesses in medical education. The authors were commissioned to carry out systematic reviews of the prevalence/incidence and causes of prescribing errors. This paper reports the prevalence/incidence of prescribing errors.

The occurrence of a prescribing error has been defined as “when, as a result of a prescribing decision or the prescription-writing process, there is an unintentional, significant reduction in the probability of treatment being timely and effective or increase in the risk of harm, when compared to generally accepted practice”.¹ The prevalence of prescribing errors in non-specialist hospitals has not hitherto been reviewed systematically. Reviews in paediatric² and mental³ healthcare found large variations in how prescribing errors were defined and how their prevalence was determined. Single-hospital studies in the United States found prescribing errors in 0.4 to 1.9% of all prescriptions written.⁴ Comparable UK research, using an estimated denominator, reported a 1.5% prevalence, a quarter of errors being serious ones.⁵ Prescribing errors increased the risk of death by a factor of 1.9, caused adverse drug events (ADEs), and increased hospital stay and cost;⁶ preventable ADEs⁷ had the greatest impact.⁶

The aim of this review was to identify systematically all informative, published evidence concerning the prevalence, incidence, and nature of prescribing errors in specialist and non-specialist⁸ hospitals, collate it, analyse it, and synthesise conclusions from it.

Methods

Identification and selection of studies

Studies were identified by searching the following electronic data bases: 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). 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 journal "Quality and Safety in Health Care" was hand searched for additional studies. The reference lists of all included studies were searched for additional studies.

Inclusion/exclusion criteria

Studies published between 1985 and 2007 that reported on the detection and rate of prescribing errors in handwritten prescriptions for adult and/or child hospital inpatients were included. Systematic reviews, RCTs, non-randomised comparative studies, and observational studies were all included. Abstracts were included if they provided sufficient data to calculate prescribing error (prevalence or incidence) rates. 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. This was to prevent the incorporation of distorted or skewed error rates in the review. Non-English language publications were excluded on the basis that there was insufficient time and resources to translate these publications.

Data extraction

A data extraction form designed for the purpose 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), definitions used, the error rate including the nature of the denominator, and any other relevant information captured by the study such as severity of errors and commonly associated medications. Two reviewers independently extracted relevant data from each study and resolved any differences through discussion. If they could not achieve consensus, a third reviewer arbitrated.

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 and percentiles error rates across studies. Some studies reported only prescribing errors whilst others reported medication errors, which included errors in the dispensing and administering processes as well as prescribing errors. Studies reporting medication errors were only included in the review if they specified the rate of prescribing errors. To facilitate comparison across studies, reported rates were converted to a common denominator. All studies reporting number of erroneous medication order(s) were converted into percentage of erroneous orders,. Studies giving rates per admission(s) were converted to rates per 100 admissions. Finally, those studies giving an incidence of errors per patient day(s) were converted into errors per 1000 patient days. After completing this it was then possible to determine the median error rate and the percentiles for the particular denominators. Studies that used estimated denominators^{5;9} were not included in this part of the analysis.

It was sometimes difficult to decide what constituted a prescription. Some studies used the term to denote one prescribed item whereas others regarded a prescription as an entire chart or list of medications for one patient. Those studies that used the term to represent a 'prescription item' were categorised with those, usually American studies, that used the term 'medication order' to denote one prescription item. Those that used the term to mean an entire chart were categorised separately. Where studies did not state what was meant by

'prescription' they were taken to mean a 'medication order' if information such as the number of prescriptions per patient indicated that to be the case.

Data concerning the types of medications involved in prescribing errors were extracted, collapsing categories of drug class as needed to present the data in a usable format as was reported by Thomsen and colleagues¹⁰ and presented in table 3. The same was done when presenting data on the types of prescribing errors.

Results

The search identified 595 articles. After initial screening of the abstracts, 493 did not meet the inclusion criteria. The remaining 114 studies were obtained in full text and assessed for their suitability to be included. The flow diagram given in figure 1 describes this process and the reasons for excluding retrieved articles.

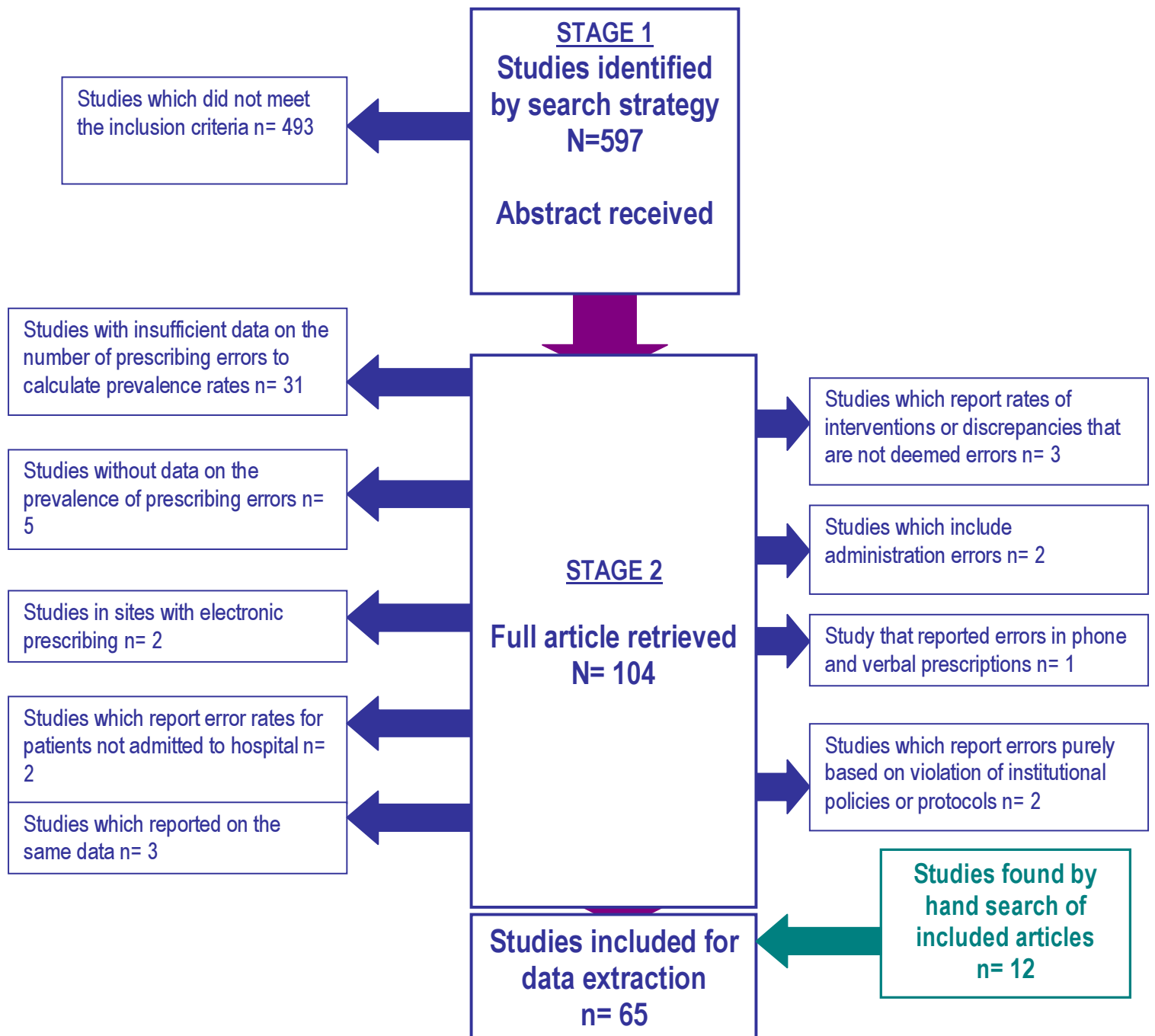


Figure 1: Flow diagram of the screening process

Settings and study design

Country and date

The graph below depicts the countries in which studies were conducted. Most studies were carried out in the USA (25/65) or UK (22/65). Other countries included Canada (n=3), The Netherlands (n=3), India (n=2), Australia (n=2), Israel (n=2), Croatia (n=1), Belgium (n=1), France (n=1), Denmark (n=1), Thailand (n=1) and Spain (n=1). Over two thirds of studies were published after 2000 (46/65)

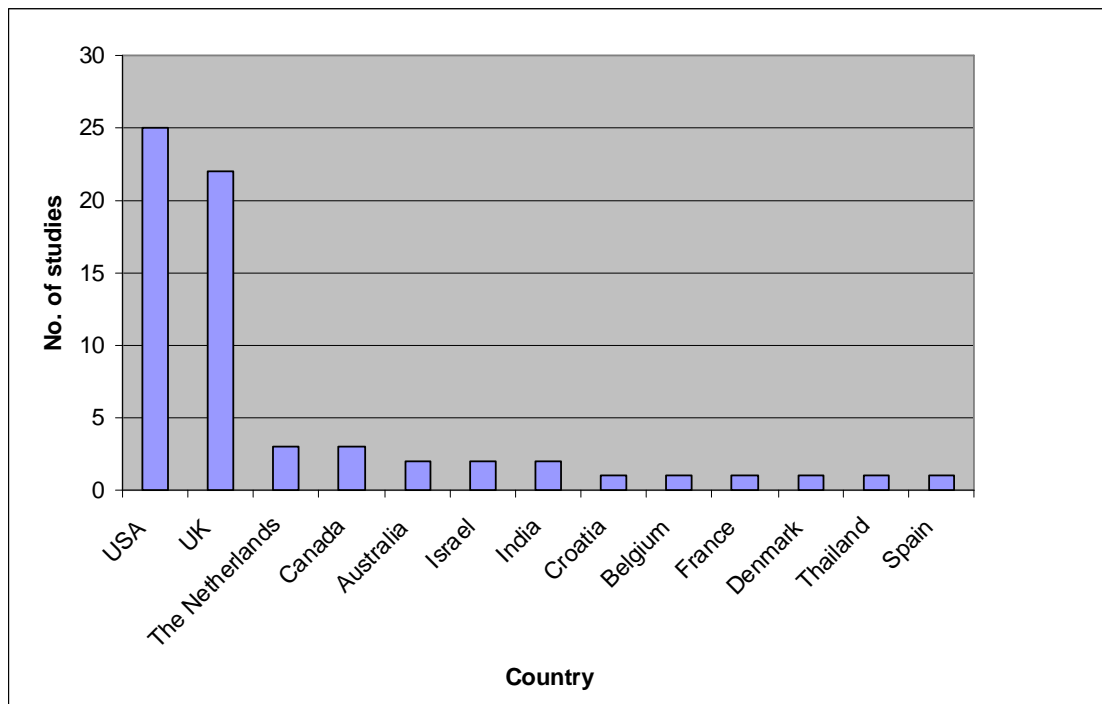


Figure 2: Graph depicting country origin of included studies

Types of hospitals

Fifty-four percent of studies (35/65) were conducted in university-affiliated hospitals. A smaller number (11/65, 17%) took place in general hospitals and four (6%) were carried out in a combination of types of hospital. Six studies (9%) were

conducted in paediatric hospitals. Two studies (3%) did not state their location. The remainder (11%) were conducted in specialist hospitals such as psychiatric ones.

Numbers of hospitals

Eighty-four percent of studies (55/65) were carried out in single hospital sites, seven studies (11%) in two hospital sites, two (3%) in nine sites^{11;12} and one (2%) in 24 sites.¹³ However, those studies carried out in more than 2 hospitals were conducted in one speciality only (paediatric intensive care unit (PICU), intensive care unit (ICU) and psychiatry).

Specialties

Thirty-eight percent of studies were carried out in adult specialities or wards only, 22% included only children's specialties or were conducted exclusively in paediatric hospitals (including one study conducted purely in neonates¹⁴), 23% included both adult and children's prescriptions, and the remaining 17% did not state the ages of the patients.

Prospective vs retrospective study designs

Most studies (89%) were prospective, 11% were retrospective. The shortest period of data collection was 4 days¹⁵ and the longest 9 years.¹⁶ Twenty-three (35%) of the studies were before and after cohort studies in which case data from only the baseline or control arm were used. Of those 23 studies, 11 set out to assess the impact of computerised physician order entry (CPOE) on the number of prescribing errors and the remainder assessed a variety of other interventions such as the participation of clinical pharmacists on ward rounds¹⁷ or the effect of educational interventions.¹⁸

Process vs outcome based

Eighty-three percent of studies were process based, meaning they reported the findings of healthcare professionals reviewing prescriptions, usually as part of

routine work.¹⁹ This type of study does not measure harm as the error is detected and reported to the prescriber before reaching the patient. Outcome based studies, which usually measure actual patient harm by reporting adverse drug events (ADEs),¹⁹ made up only 3% of included studies. A small proportion (14%) of studies were both process and outcome based in that they investigated both incident reports (some of which included actual adverse drug events [ADEs]) and prescribing errors detected in the prescription itself.

Method of detection

The most frequent method of detecting errors (38%) was screening of prescriptions as part of pharmacists' normal duties. Eighteen percent of studies also included prescription or prescription chart review, which was not necessarily part of routine work and which was also sometimes carried out by healthcare professionals other than pharmacists. Four studies (6%) detected prescribing errors by a review of patient records and five studies (8%) used incident reporting. Nearly a third of studies (27%) used a combination of the above methods and some even included additional methods such as stimulated self report,²⁰ medication reconciliation²¹ and interviews with other healthcare professionals.²² Two studies did not state how they identified prescribing errors.^{23;24}

Data collectors

Pharmacists, physicians, and nurses were the usual data collectors. Pharmacists were the most frequently cited of them (83%), reflecting the high number of process based studies. Thirteen percent of studies did not say who collected the data.

Specialties included

Twenty-nine percent of studies included prescriptions from all or the vast majority of wards and specialities within the study site(s). The remainder only provided error rates for a single ward or a limited number of specialties.

Validation review

Some studies would employ a process to check the validity of the collected prescribing errors. Examples included the formation of a panel of clinicians to review whether the reported errors fell within the definitions used by the study and their classification. Also, some studies would involve discussion with the original prescriber in order to validate the claim that a prescribing error had occurred. There may be occasions when the data collector is unaware of information that the prescriber had at the time which would invalidate the decision to classify a prescription as erroneous. However, fewer than half of the studies (27/65) included some type of review of the errors themselves, such as determination by a panel of clinicians as to whether reported errors fell within study definitions, and only twenty-eight percent of studies (18/65) checked reported errors with the prescribing doctor. Studies that did not review errors more commonly used some type of consensus technique to rate the severity of errors. Twenty-three percent of studies (15/65) did not incorporate any process of review.

Definitions

The definition of a prescribing error varied tremendously, 42% of studies (27/65) providing definitions of their own or deriving from previous research. Eleven studies (17%) used a standard definition developed by Dean et al.¹ The twelve studies (18%) recording medication errors or adverse drug events (ADEs) provided appropriate definitions, using American Society of Health-System Pharmacists (ASHP) criteria in two studies and the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) criteria in another two studies. Nearly a quarter of studies (23%) did not state any definitions at all. Even when definitions were given, some were as subjective as a prescribing error is 'a prescription not appropriate for the patient'²⁵ 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'.²⁶ Others were very specific: '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.¹¹

Prevalence rates

Several denominators were used: Medication orders, prescription charts, admissions, and patient days. Table 1 presents the main finding of the review, listing median values and quartiles for the various denominators.

Medication orders as denominator

Thirty-three studies, listed in table 2, used medication orders as denominator with a median of 7% of erroneous medication orders.

Admissions as denominator

Nineteen studies, listed in table 2, used admissions as denominator with a median rate of 52 errors per 100 admissions.

Patient days as denominator

Eleven studies, listed in table 2, used patient days as denominator with a median rate of 24 errors per 1000 patient days.

Prescription charts as denominator

Five studies^{14;24;27-29} either explicitly used prescription charts or did not clearly state their denominator (whether medication item or chart).

Table 1: Median, percentiles and range of error rates.

Type of error rate	Median	Percentiles	
		25	75
% of erroneous medication orders	7	2	14
Errors per 100 Admissions	52	8	227
Errors per 1000 patient days	24	6	212

Table 2: Studies reporting error rates per medication orders, per admission or per patient day

(see key at end of table for abbreviations or see glossary)

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Anderson, J.G. et al ^{30,31} (2002/1997)	USA	Teaching hospital (n=1)	2 medical-surgical wards	12 weeks	NS	P	Process based	Pharmacist order review	6966	32*	4.6 errors per 1000 medication orders
Aneja, S. et al ³² (1992)	India	Paediatric hospital (n=1)	General paediatric ward	2 months	C	P	Process based & outcome based	Incident reports	700	17	2.43 errors per 100 admissions
Barber N, et al ^{33*} (2006)	UK	One teaching hospital & one general hospital (n=2)	Site 1: general surgery ward. Site 2: paediatrics, CoE, surgery, medical wards	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% Site2: 8.6% or Site 1:212 Site2:290 of medication orders or per 1000 patient days
Bates, D.W. et al ³⁴ (1995)	USA	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	3.18 or 5.98 errors per 100 admissions or per 1000 patient days
Bobb, A. et al ³⁵ (2004)	USA	Teaching hospital (n=1)	Inpatient and ED	1 week	A	P	Process based	Detected as part of usual screening by pharmacists	17,808	1111	6.2% of medication orders

* The authors gave a rate of prescribing errors but did not state the number of prescribing errors therefore this has been calculated

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Blum, K.V et al ³⁶ (1988)	USA	Teaching hospital (n=1)	NS	3 months	A&C	P	Process based	Detected as part of usual screening by pharmacists	Adults: 75,333 Children: 48,034	Adults: 1,012 Children: 1,277	1.9% of medication orders
Cimino, M.A. et al ¹¹ (2004)	USA	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 ^{37*} (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 per 1000 patient days
Dale, A. et al ³⁸ (2003)	UK	General hospital (n=1)	2 general medical wards	12 weeks	A	P	Process based & outcome based	Detected as part of usual screening by pharmacists & drug history interview	122	394	323 errors per 100 admissions

[†] The authors gave a rate of prescribing errors but did not state the number of prescribing errors therefore this has been calculated

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Dean-Franklin, B. et al ⁵ (2002)	UK	Teaching hospital (n=1)	All non-obstetric patients included	4 weeks	A&C	P	Process based	Detected as part of usual screening by pharmacists	36,200 [♦]	538	1.5% [♦] of medication orders
Dobrzanski, S. et al ⁹ (2002)	UK	Teaching hospital (n=1)	All wards accept prescribing in theatres & thromboprophylaxis	1 month	A&C	P	Process based	Detected as part of usual screening by pharmacists	800,000 [♦]	587	3.5- 7 [♦] errors per 1000 medication orders
Edwards, K.L. et al ²³ (1996)	USA	Teaching hospital (n=1)	All	3 months	NS	P	Process based	NS	89,628	343	3.83 errors per 1000 medication orders
Folli, H.L. et al ^{39*} (1987)	USA	Children's hospitals (n=2)	All wards	6 months	C	P	Process based	Detected as part of usual screening by pharmacists	57,394 & 43,268 (total no. patient days not stated)	281& 198	0.5% or 13.7 & 17.9 of medication orders or per 1000 patient days

♦ Estimated denominator

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Forster, A.J. et al ²⁰ (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 per 1000 patient days
Fowlie, F. et al ²⁵ (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 ⁴⁰ (1997)	USA	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 ⁴¹ (2007)	UK	Teaching hospital (n=1)	Medical directorate with 10 specialties (20 wards)	Feb-May 05	NS	P	Process based	Detected as part of usual screening by pharmacists	4995	474	9.2% of medication orders
Franklin, B.D. et al ⁴² (2007)	UK	Teaching hospital (n=1)	28 bed general surgical ward included	4 weeks	A	P	Process based	Detected as part of usual screening by pharmacists	2450 [♦]	93	3.8% [♦] of medication orders
Gethins, B. et al ¹⁸ (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 ⁴³ (2005)	USA	NS (n=1)	NS	2 months	C	P	Process based	Pharmacist order review	272	39	14.3% of medication orders

[♦] Estimated denominator (pre-intervention)

[‡] 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 medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Grasso, B.C. et al ⁴⁴ (2003)	USA	Psychiatric hospital (n=1)	All wards	5 months	A	R	Process based	Record review	1448	239	165 per 1000 patient days
Haw, C. et al ¹⁵ (2003)	UK	Psychiatric hospital (n=1)	All wards included	4 days	Adults and adolescents	P	Process based	Detected as part of usual screening by pharmacists	2274*	50	2.2% of medication orders
Hendey G.W. et al ⁴⁵ (2005)	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	8,195	177	2.2% of medication orders
Ho, L. et al ⁴⁶ (1992)	Canada	Teaching hospital (n=1)	All wards	25 weeks	NS	P	Process based	Detected as part of usual screening by pharmacists	237,798	1330§	5.6 per 1000 medication orders
Johnson, K.B. et al ⁴⁷ (1996)	USA	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

* Estimated prescription items checked on 4 days

§ Figure includes non-formulary and hospital policy variation

Study	Country	Study sites	Setting	Study period	Adults/ children	Type of study	Type of data collection	Method of error detection	Total medication orders/ admissions/ patient days	No. prescribing errors	Rate of errors
Kaushal, R. et al ^{48*} (2001)	USA	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 per 1000 patient days
King, W.J. et al ⁴⁹ (2003)	USA	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 per 1000 patient days
Leape, L.L. et al ⁵⁰ (1999)	USA	Teaching hospital (n=1)	Medical ICU (intervention unit) & coronary care unit (control unit)	6 months & 10 months	A	R	Outcome based	Record review	1892	24	12.7 per 1000 patient days
Lepaux, D.J. et al ⁵¹ (2002)	France	Specialist hospital (n=1)	NS but all prescriptions going to pharmacy included	75 days	Unclear	P	Process based	Detected as part of usual screening by pharmacists	15,699	302	1.9%** of medication orders

** Includes unauthorised drugs

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Lesar, T.S. et al ^{4;16;52*} (1997)	USA	Teaching hospital (n=1)	All patients admitted to the hospital	9 years	A&C	P	Process based	Detected as part of usual screening by pharmacists	3,903,433 or 211,635 or 1,715,649	11,186	0.3% or 5.29 or 6.52 of medication orders or errors per 100 admissions or per 1000 patient days
Lisby, M. et al ⁵³ (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
Lustig, A. et al ⁵⁴ (2000)	Israel	General hospital (n=1)	All wards	6 months	A&C	P	Process based	Detected as part of usual screening by pharmacists	14,385	160	11.1 per 1000 medication orders
McFadzean, E. et al ²² (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
Morrill, G.B & Barreuther, C. ²⁶ (1998)	USA	Veterans hospital (n=1)	NS	7 days	NS	P	Process based	Pharmacist order review	668	103	15.4% of medication orders
Oliven, A. et al ⁵⁵ (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

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Olsen, S. et al ⁵⁶ (2007)	UK	General hospital (n=1)	Patient cases chosen from 3 general medical & 3 general surgical teams	NS	A	P	Process based & outcome based for actual ADRs	Record review, incident reporting & prescription review	288	41	14.2 errors per 100 admissions
Parke, J. et al ⁵⁷ (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 ⁵⁸ (2007)	India	Teaching hospital (n=1)	3 medical wards	NS	A & C	P	Process based	Chart review & record review	304	157	51.6 errors per 100 admissions
Potts, A.L. et al ⁵⁹ (2004)	USA	Teaching hospital (n=1)	20 bed critical care unit	2 months	C	P	Process based	Pharmacist order review	6803	2049	301.2 errors per 1000 medication orders
Rees, S. et al ⁶⁰ (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
Ridley, S.A. et al ¹³ (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 ⁶¹ (2002)	UK	Teaching hospital (n=1)	Surgery wards (& pre-operative assessment clinic)	2 months	A	P	Process based	Prescription review and chart review	76	177	232.9 errors per 100 admissions

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Sangtawesin, V. et al ⁶² (2003)	Thailand	Teaching hospital (n=1)	NS	15 months	C	P	Process based and outcome based for actual ADRs	Incident reports	32,105	114	0.4 errors per 100 admissions
Scarsi, K.K. et al ¹⁷ (2002)	USA	Teaching hospital (n=1)	All patients admitted to the general medicine service	1 month	A	R	Process based	Chart and record review	35	48	137.1 errors per 100 admissions
Schumock, G.T. et al ^{63;64} (1994)	USA	Teaching hospital (n=1)	2 medicine services	60 days	NS	P	Process based	Detected as part of usual screening by pharmacists	294	17	5.8% of medication orders
Shulman, R. et al ⁶⁵ (2005)	UK	Teaching hospital (n=1)	1 unit in each site	9 days	A	P	Process based	Detected as part of usual screening by pharmacists	1036	69	6.7% of medication orders
StClair, A.T. et al ⁶⁶ (1995)	NS	Paediatric teaching hospital (n=1)	All	NS	C	P	Process based	Detected as part of usual screening by pharmacists	14,595	356	2.4% of medication orders
Stubbs, J. et al ¹² (2006)	UK	Mental health institutions (n=16)	All	5 days	A&C	P	Process based	Detected as 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 medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Terceros, Y. et al ⁶⁷ (2007)	USA	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 ⁶⁸ (1991)	USA	Teaching hospital (n=1)	Intensive care	6 months	A	P	Process based	Detected as part of usual screening by pharmacists	41,776	463	1.1% of medication orders
Tully MP et al ^{8*} (2006)	UK	One teaching hospital & one general hospital (n=2)	Site A: medical & CoE. Site B: Heart care unit & whole hospital	1 year	Site A: A Site B: A&C	Site A: R Site B: P	Process based	Record review & chart review	HU: 1279 & whole hospital: 33,012	HU: 100; whole hospital: 3463	HU: 7.7% whole hospital: 10.5% or 190; whole hosp: 40 of medication orders or errors per 100 admissions
Van den Bemt, P.M.L.A. et al ⁶⁹ (2002)	The NLS	One teaching hospital & one general hospital (n=2)	All wards	5 days	A&C	P	Process based	Detected as part of usual screening by pharmacists	3540	351	9.9% of medication orders

Study	Country	Study sites	Setting	Study period	Adults/children	Type of study	Type of data collection	Method of error detection	Total medication orders/admissions/patient days	No. prescribing errors	Rate of errors
Van Gijssel-Wiersma, D.G. et al ⁷⁰ (2005)	The NLs	General hospital (n=1)	32 bed internal medicine unit	3 weeks	A	P	Process based	Detected as part of usual screening by pharmacists	611	124	20.3% of medication orders
Vira, T. et al ²¹ (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 ⁷¹ (2007)	USA	Teaching hospital (n=1)	All paediatric wards	3 months	C	P	Process based	Detected as part of usual screening by pharmacists	16,938	464	2.7% of medication orders
Webbe, D. et al ⁷² (2007)	UK	Teaching hospital (n=1)	4 wards	9 weeks	A	P	Process based	Detected as part of usual screening by pharmacists	302	73	24.2% of medication orders
West, D.W. et al ⁷³ (1994)	USA	Paediatric hospital (n=1)	All wards	3 months	C	P	Process based	Pharmacist review & incident reporting	7056	60	8.5 errors per 1000 medication orders
Wilson, D.G. et al ⁷⁴ (1998)	UK	Teaching hospital (n=1)	Paediatric cardiac ward & 4 bed paediatric cardiac ICU	2 years	C	P	Process based and outcome based for actual ADRs	Incident reports	682	302	44.3 errors per 100 admissions

KEY

A = Adults
C = Children
NS = Not stated
P = Prospective
R = Retrospective

Types of medications

Twenty-two studies (34%) detailed the medications most strongly associated with prescribing errors. Four studies^{20;34;48;71} included information about the classes of medication associated with medication errors but the prevalence of prescribing errors could not be determined. Studies providing quantitative data regarding the types of medication commonly associated with prescribing errors are listed in table 5. Antimicrobials, with a prevalence of 32% of prescriptions, were most strongly associated, particularly in children where 5 out of 5 studies found antibiotics most strongly associated.

Cardiovascular medications were also strongly associated with a 17% prevalence of errors. Drugs acting on the central nervous system, with a median prevalence of 8%, were most strongly associated in 3 studies. Fluids, electrolytes, and parenteral nutrition were also commonly reported with a prevalence of 9%. Other medications commonly associated were analgesics and gastrointestinal medications.

Table 3: Studies reporting types of medication associated with prescribing 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 ²⁷	27	35	7	NA	NA	7	NA	6	NA	NA
Bobb, A. et al ³⁵	37	12.3	2.9	7.6	3.2	NA	3.2	3.8	NA	NA
Colpaert, K. et al ³⁷	23.5	23	19.8 ^h	NA	NA	NA	NA	NA	NA	NA
Edwards, K.L. et al ²³	35	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fijn, R. et al ⁶²⁴	NA	NA	25	NA	20	12	NA	NA	NA	NA
Folli, H.L. et al ³⁹	35.9	1.7	3.1	8.8	NA	11.3	3.8	16.9	0.8	NA

*Only 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
Ho, L. et al ⁴⁶	23.7	8.3	14.3	NA	6.5	1	5.3	8.9	0.5	NA
Lesar, T.S. et al ¹⁶	35.7	18.3	5	10.6	7	4.5	5.8	3.3	NA	1.1
Lustig, A. et al ⁵⁴	38.7	15.1	NA	NA	5	NA	NA	21.8	15.6	NA
Pote, S. et al ⁵⁸	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 ¹³	12.5	24.2	16.1	1.7	5.3	3.9	4.1	19.9	NA	NA
Sangtawesin, V. et al ⁶²	32.4	8.97	5.77	6.09	8.33	6.41	5.13	18.59	4.49	NA
Togashi, C.T. et al ⁶⁸	23	15	NA	NA	14	NA	NA	NA	NA	NA

Reference	Anti-microbials ^a	CVS ^b	CNS ^c	Analgesics ^d	GI	Respiratory ^e	Endocrine ^f	Blood and nutrition ^g	Anti-neoplastics	Anti-allergic
Van den Bent, P.M.L.A. et al ⁶⁹	NA	21	32 ^h	NA	20	11	NA	NA	NA	NA
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

Types of error

Sixty-five percent of studies (42/65) reported the types of errors. Table 6 lists studies that reported types of errors (excluding those that focused on just one stage of patient admission) and show the percentage of the total number of errors identified. This classification process was dependent upon the definition of a prescribing error used within the study. By far the commonest errors (18/33 studies) were dosage errors, the remainder being accounted for by errors of omission, where medications had not been prescribed but were indicated (5 studies), incomplete prescriptions in which a medication had been prescribed but the prescription had incomplete information regarding, for example, the route of administration (4 studies), illegibility, errors in dosage interval, incorrect formulation, drug-drug interactions, and transcription errors (the remaining 7 studies). Errors not included in the table but reported in some studies related to the need for therapy, monitoring, patient identity errors, transcription errors, contra-indications, use of non-formulary and unauthorised drugs, and prescriptions that did not accord with the BNF.

Seven studies^{32;39;62;66;74} listed the most frequent types of prescribing errors in paediatric practice. Five of the seven (71%) found dosage errors to be most common, and the remaining two studies found errors of omission to be most common.^{43;59}

Table 4: Studies reporting types of prescribing error (%)

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 ³²	41.18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Baci, V.V. et al ²⁷	44.33	35.36	NA	NA	18.21	NA	NA	NA	NA	NA	NA	NA
Bobb, A. et al ³⁵	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 ³⁶	45	27	11	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dean-Franklin, B. et al ⁴²	54	NA	13	6	NA	NA	NA	NA	9	NA	NA	NA
Dobrzanski, S. et al ⁹	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 ²³	35	NA	25	NA	NA	NA	NA	NA	NA	NA	NA	NA

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

† overdose only

‡ includes duplication

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy**	Illegible	Medication s omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature / abbreviation	Allergy
Fijn, R. et al ²⁴	62.81	8.5	NA	NA	4.9	3.1	NA	NA	NA	4.9	NA	NA
Folli, H.L. et al ³⁹	82	NA	NA	5.6	NA	NA	NA	1.9	NA	NA	NA	0.4
Franklin, B.D. et al ⁴²	48.4	NA	14	2.2	NA	NA	NA	NA	10.8	NA	NA	NA
Gethins, B. et al ¹⁸	NA	5.6	NA	13.7	11.3	1.1	NA	NA	NA	NA	66	NA
Grasso, B.C. et al ⁴⁴	10.9	NA	51.8	NA	6.3	5.4	NA	NA	NA	NA	NA	NA
Haw, C. et al ¹⁵	1.9*	3.2	43.4	NA	3.9	10.2	NA	NA	NA	NA	3.2	NA
Hendey, G.W. et al ⁴⁵	42	17	NA	34	NA	NA	NA	NA	NA	NA	NA	2

* under dose only

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy**	Illegible	Medication s omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature / abbreviation	Allergy
Ho, L. et al ⁴⁶	18.7	NA	27.7	NA	NA	9.9	NA	NA	NA	NA	NA	NA
Lepaux, D.J. et al ⁵¹	NA	2.7	NA	3.6	NA	15.9	NA	NA	NA	4.3	NA	NA
Lesar, T.S. et al ¹⁶	56.1	NA	NA	4.1	6.1	NA	NA	3.5	NA	NA	NA	14.4
Lisby, M. et al ⁵³	NA	5.5	NA	NA	NA	NA	NA	NA	43.8	10	1.2	NA
Lustig, A. et al ⁵⁴	27.5	NA	NA	NA	NA	NA	NA	NA	NA	1.3	12.5	NA
Olsen, S. et al ⁵⁶	NA	30	NA	7	NA	NA	50	3	NA	3	NA	NA
Pote, S. et al ⁵⁸	9.6	12.1	5	1.3	NA	NA	NA	NA	NA	NA	NA	1.3

* not all errors only those detected by pharmacy surveillance

Author (s)	Dosage errors	Frequency/ dosage schedule	Incomplete Prescriptions	Incorrect drug	Duplicate therapy**	Illegible	Medication s omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature / abbreviation	Allergy
Potts, A.L. et al ⁵⁹	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 ¹³	4.4	NA	NA	NA	4.7	9.6	2.1*	NA	9.4	8.2	11.2	NA
Sangtawesin, V. et al ⁶²	25.78	NA	NA	3.73	NA	NA	NA	NA	NA	NA	NA	0.62
Scarsi, K.K. et al ¹⁷	Intervention group:46.7 Control group:52.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Schumock, G.T. et al ^{63;64}	11.8	41.2	23.5	5.9	NA	NA	5.9	NA	NA	NA	NA	NA
Shulman, R. et al ⁶⁵	16.9	NA	31	NA	NA	NA	NA	7	11.3	NA	NA	NA
StClair, A.T. et al ⁶⁶	30.6	NA	28.7	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	Medication s omitted	Incorrect route	Instructions for use and admin	Duration of treatment	Incorrect drug name/ nomenclature / abbreviation	Allergy
Stubbs, J. et al ¹²	NA	9.8	27.5	NA	1.9	NA	NA	NA	NA	2.7	NA	NA
Togashi, C.T. et al ⁶⁸	33	NA	18	NA	NA	NA	NA	NA	NA	NA	NA	NA
Van den Bemt, P.M.L.A. et al ⁶⁹	5.4	NA	6.3	NA	8	NA	NA	NA	44.1	NA	7.7	NA
Van Gijssel- Wiersma, D.G. et al ⁷⁰	43	NA	NA	NA	21	NA	NA	NA	NA	NA	NA	NA
Wilson, D.G. et al ⁷⁴	22.5	9.3	21.5	9.3	NA	2.3	NA	NA	NA	NA	NA	NA

Severity of 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 the data. Of those that reported severity, three studies^{35;69;70} rated severity according to their own modification of the NCCMERP index for categorising medication errors.⁷⁵ One study⁶⁰ used criteria set out by the National Patient Safety Agency Risk⁷⁶ to rate severity and two studies^{36;64} based their criteria on the previous work of others such as Folli et al.³⁹ The remainder of studies provided their own classification of prescribing error severity with little similarity between them. This disparity made it impossible to compare severity across studies.

Discussion

This review has a number of important findings. Prescribing errors are an international problem but there is remarkable variability in reported error rates. This variability can partly be explained by differences in study methodology; for example, outcome based studies inevitably yield much lower error rates than process based studies as actual patient harm is not an inevitable outcome of a prescribing error. However, that methodological consideration does not provide a complete explanation for the observed 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 because of underreporting. Review of patient records identified more errors but still only those noted in the records and therefore vulnerable to incomplete documentation.⁷⁷ 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 comprehensive⁷⁸ and accurate, yet there was still great variation between studies using that method of error detection. Furthermore, use of more than one means of error detection introduced yet further variability.

Another major influence on our findings was inconsistency in the definition of errors, many studies using their own bespoke definitions. To illustrate how that could affect reported error rates, some studies regarded deviation from a hospital formulary or policy as a prescribing error, whereas others did not. A few studies included procedural errors, such as one study which regarded the prescription of branded medication as an error.¹⁸ This source of variability has been identified previously as a major problem, which resulted in the formulation of a practitioner led definition of a prescribing error.¹ That definition was the one most commonly used yet only 14% of all studies used it.

Limitations of included studies

As well as variability, individual studies had limitations. A common one was poor classification of errors. Many studies did not report any system of error validation. Most did not state whether there was any discussion of errors with the original prescriber. One study found that 13% of errors detected by a pharmacist were not accepted by the prescriber,⁵⁴ suggesting a discrepancy between the observer's and the prescriber's perception 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.⁴¹ Few studies commented self-critically upon this source of unreliability.

Other limitations included 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 likely affected the reported rates and types of prescribing errors. Some studies were conducted in specific contexts such as psychiatric hospitals¹⁵ or intensive care units¹³ while others focussed on a particular stage of patient stay such as admission^{22;43;60} or discharge.^{26;47;64} These studies showed higher numbers of particular types of errors such as duplication or errors of omission.

Limitations of the review

This review was limited to English language publications and was hampered by the lack of standardisation across studies, which made the processes of analysis and critical appraisal difficult. Our conclusions are restricted by the predominance of observational studies. Our critical appraisal of the studies was hindered by the limited methodological information they often gave.

Recommendations

Errors of dosage were the most commonly reported type of prescribing error found in this review, a finding that was also reported from a systematic review of medication

errors in children.² That provides an obvious target for preventive measures, some of which are already being put into place in the form of computerised physician order entry (CPOE) systems. Interestingly, some studies we reviewed were designed to determine the effect of CPOE on prescribing error rate and they found improvements in dosage errors and errors of omission. However, this technology also resulted in new types of prescribing errors.³⁷ Many studies found antimicrobials associated with a high proportion of prescribing errors across many studies, providing an obvious target for educational strategies or service developments. The lack of standardisation and heterogeneity of studies was a huge barrier to understanding the extent of prescribing errors and is an obvious development area for pharmacy research. If such changes were made, the results of individual studies could more confidently be combined, providing a far clearer picture of the nature of prescribing errors. What was also apparent from this review was the importance of healthcare professionals in the process of error detection. Pharmacists seemed particularly well placed to collect data on errors and were commonly recruited for that purpose.

Conclusions

Studies from a variety of countries have attempted to capture the rate of prescribing errors within a range of hospital institutions, yet it remains impossible to quote an overall rate with any confidence. Comparison across studies is inhibited by great variation in study methodology and numerous other confounding variables. This heterogeneity and lack of standardisation means the true picture of prescribing errors remains elusive. However, regardless of the variability of reported rates, the importance of prescribing errors is not in question and careful investigation of the reasons behind prescribing errors may provide new insight and opportunities for change.

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