

Medication errors in a paediatric teaching hospital in the UK: five years operational experience

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Abstract

Background—In the past 10 years, medication errors have come to be recognised as an important cause of iatrogenic disease in hospital patients.

Aims—To determine the incidence and type of medication errors in a large UK paediatric hospital over a five year period, and to ascertain whether any error prevention programmes had influenced error occurrence.

Methods—Retrospective review of medication errors documented in standard reporting forms completed prospectively from April 1994 to August 1999. Main outcome measure was incidence of error reporting, including pre- and post-interventions.

Results—Medication errors occurred in 0.15% of admissions (195 errors; one per 662 admissions). While the highest rate occurred in neonatal intensive care (0.98%), most errors occurred in medical wards. Nurses were responsible for most reported errors (59%). Errors involving the intravenous route were commonest (56%), with antibiotics being the most frequent drug involved (44%). Fifteen (8%) involved a tenfold medication error. Although 18 (9.2%) required active patient intervention, 96% of errors were classified as minor at the time of reporting. Forty eight per cent of parents were not told an error had occurred. The introduction of a policy of double checking all drugs dispensed by pharmacy staff led to a reduction in errors from 9.8 to 6 per year. Changing the error reporting form to make it less punitive increased the error reporting rate from 32.7 to 38 per year.

Conclusion—The overall medication error rate was low. Despite this there are clear opportunities to make system changes to reduce error rates further.

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Keywords: children; medication errors

The *United States Pharmacopeia* defines medication errors as any preventable event that may cause or lead to an inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer.¹ A number of types of medication errors, such as prescribing errors or medication administration errors, have been recognised.² The various categories are not mutually exclusive because the origins of errors are often multiple.

In the past 10 years, medication errors have come to be recognised as an important cause of iatrogenic disease in hospital patients.³⁻⁶ While many errors are minor, those associated with morbidity and mortality increase health care costs and can be a source of litigation. Much of the published information documenting the incidence and type of medication errors occurring in patients in hospitals comes from North America.^{3 5 7 8} There, paediatrics ranked sixth among 16 medical specialties in frequency of medication related litigation claims. However, paediatrics had twice the average reported settlement of other specialties at \$292 136 per case.⁹ Despite this, and apart from case reports, advice, and guidelines, little has been published on medication errors in children in hospital.¹⁰⁻¹⁴

The situation in the UK seems strikingly different overall, with little published data on medication errors in any age group. There is no national requirement that hospitals should evaluate iatrogenic errors and many hospitals apparently have no systems in place for the systematic recording of medication errors.

At the Royal Hospital for Sick Children, Glasgow, Scotland, a hospital wide medication error reporting system has been in place for five years. During this time, the hospital Audit Committee has reviewed aggregated error data and promulgated a number of changes in an attempt to reduce errors. In the present study, we reviewed the incidence and type of errors reported in the five years since the scheme was established and the impact of the changes made. We were particularly interested in comparing data from a routine error review system in a hospital in a nationally funded universal health care system with data from the insurance based health system prevalent in North America.

Subjects and methods

This study reviewed data collected in the Royal Hospital for Sick Children (RHSC), Glasgow and its adjacent tertiary referral neonatal intensive care unit (NICU) in the Queen Mother's Maternity Hospital. The hospital is one of the largest paediatric teaching hospitals in the UK with 303 inpatient beds (12 paediatric intensive care (PICU), 146 medical, and 145 surgical). There is also a paediatric emergency department seeing 34 000 cases annually and a maternity unit with 3600 deliveries a year. The associated neonatal unit has 28 cots.

A hospital wide medication error reporting policy was established at RHSC, Glasgow in February 1994 with reporting beginning in April 1994. The medication error policy applied in all areas of the hospital and was

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Table 1 Date and clinical area where errors occurred

Date	4/94-1/95	2/95-1/96	2/96-1/97	2/97-1/98	2/98-1/99	2/99-8/99	Total
Total no.	29	31	28	46	36	25	195
Medical	19	20	7	33	22	14	115
Surgical	5	5	10	2	1	2	25
NICU	2	5	5	7	9	5	33
PICU	3	1	5	3	4	4	20
Theatre	0	0	1	1	0	0	2

mandatory for all staff, failure to report an error being considered a disciplinary matter. The policy also defined what constituted a medication error (listed in the Appendix). Reports were collected on standardised forms available in all departments; all error reports were then investigated by the head of department. The director of pharmacy prepared a quarterly summary report that was submitted to the Hospital Board, Management Group, and the Clinical Audit Committee.

In the present study, we reviewed all errors reported and the associated investigations between April 1994 and August 1999.

STATISTICAL METHODS

Data were summarised using standard descriptive methods. Error rates were calculated using either aggregated monthly admission rates or total bed days as the denominators.

Results

A total of 195 errors were reported over a 65 month period. The occurrence of errors varied little over the five years (table 1).

An attempt was made to ascertain the amount of drugs administered over the time period of the study. Unfortunately, the hospital does not have a computerised prescribing system and no data on the total number of prescription orders are available. However, the total number of antibiotic vials ordered by pharmacy in the first and last years of the study were similar (81 312 versus 80 478 vials), suggesting that major changes in the numbers of drugs prescribed are unlikely.

Between April 1994 and March 1999 (the latest date for which inpatient statistics are available) there was a total of 112 536 admissions and 335 835 patient bed days.

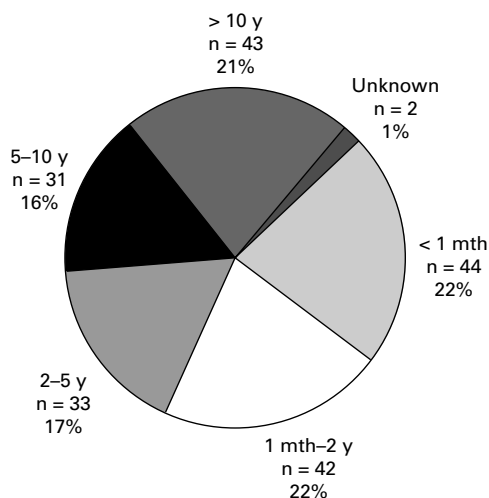


Figure 1 Age of children involved in medication error.

Table 2 Type of error

Classification of error	No. (%)
Incorrect intravenous infusion rate	32 (15.8)
Incorrect dose administered	30 (14.8)
Extra dose given	28 (13.8)
Dose omitted	25 (12.3)
Incorrect drug given	25 (12.3)
Incorrect intravenous concentration	21 (10.3)
Labelling error	20 (9.9)
Incorrect route of administration	9 (4.4)
Incorrect patient	8 (3.9)
Incorrect strength	1 (0.5)
Other	4 (2)

During the same period, there were 2602 admissions to PICU, resulting in 9959 bed days. There were 3373 admissions to NICU, resulting in 28 796 bed days. During the same period, 170 errors were reported, giving an overall error rate of 0.15% admissions (one error per 662 admissions) or 0.51 per 1000 bed days (one error per 1976 bed days). Reported error rates varied between each department (table 1), being highest in the NICU (0.98%) and PICU (0.77%). Non-intensive care areas had lower rates (medical unit 0.22%) with the lowest rate reported in the surgical unit (0.04%).

Figure 1 illustrates the age distribution of patients involved. Eighty six (44%) of the errors occurred in children under 2 years of age. One fifth of all errors occurred in patients during the first month of life. The error rate in other age groups was more evenly spread.

The majority of errors, 115 (59%), occurred in medical wards. Of the remainder, 25 (13%) occurred in surgical wards, 33 (17%) in NICU, 20 (10%) in PICU, and two (1%) in theatre. Nursing staff reported most errors (115; 59%), reflecting the fact that most drugs are now given by nurses. Medical staff, either alone or in conjunction with another member of staff, made 41 (21%) errors. Pharmacy dispensing staff were responsible for 39 (20%) errors. Most errors, 130 (67%), occurred despite checking by two people, but in 58 (30%) cases double checking did not occur, while in seven (3%) it was not known whether checking occurred or not.

Table 2 lists the types of errors. Eight incidents involved more than one category. Fifty six per cent (109) of the 195 incidents involved drugs given via the intravenous route. Table 3 profiles the intravenous drugs involved. Oral medication errors occurred in 66 (34%) cases, while other routes accounted for 20 (10%).

Fifteen (8%) incidents involved a tenfold error, of which five occurred because of miscalculation of dose despite clear prescribing. Four

Table 3 Types of intravenous drug involved in reported errors

Type of drug involved	n (%)
Antibiotic/antiviral	48 (44)
Parenteral nutrition/intravenous fluids	18 (16.5)
Anticancer drugs	11 (10.1)
Inotropes	6 (5.5)
Morphine	5 (4.6)
Steroids	5 (4.6)
Insulin	4 (3.7)
Other	12 (11)

were caused by incorrect or unclear prescribing and one was a result of inaccurate verbal communication. Five of the 15 arose because of errors setting the rate on an infusion pump.

There were 23 intravenous pump errors with between three and six per year; the rate did not change with time. In 1994, there were 16 different types of syringe pump and seven different types of volumetric pump in use throughout the hospital. Currently, there are still 16 types of syringe pump (a maximum of six in any one department) and four types of volumetric pump in use.

Medical staff assessing patient outcome classified 96% of errors as minor—that is, no actual harm resulted. Three were classified as of medium severity (clinical symptoms were aggravated by the error), while only two (1%) were classified as serious (there was potential severe harm). There were no cases of long term morbidity or mortality. Of the two errors classified as serious, one involved the administration of the wrong concentration of a chemotherapeutic agent, while in the other the rate of infusion of a major sedative was 100 times too high. Although only 4% of errors were classified as other than minor, 18 (9.2%) errors required active patient intervention: 10 involved blood sampling, for example, electrolyte or glucose monitoring, or drug concentration measurement; and four required another drug to be administered to mitigate the error (two children received hydrocortisone and chlorpheniramine, one intravenous naloxone, and one intravenous frusemide).

Analysis of the reporting forms showed that 48% of parents were not informed that an error had taken place.

During the period under review, there have been a number of changes in training and practice around drug administration. From August 1994, a junior doctor induction programme was introduced covering practical aspects relevant to their job. This programme included instruction by a senior paediatric pharmacist on good prescribing practice. Paediatric formularies were supplied to all junior staff. From August 1997, intravenous training has also been provided to all junior medical staff from commencement of employment, concentrating mainly on the preparation of chemotherapeutic agents. Reported errors involving doctors have varied slightly from year to year, being six per year at the start and three per year at the end.

Since January 1996, it has been pharmacy policy that two people should check all drug dispensing. In the 22 month period before this time, 18 reported errors were attributed to drug dispensing—that is, 9.8 errors per year. The majority of these were labelling errors that were detected and prevented by nursing staff before administration. Only 21 occurred (six per year) in the subsequent 43 months.

In May 1998, increased training was provided for all nursing staff initiating intravenous drug administration. Before May 1998 a total of 152 errors occurred (37 per year on average). In the subsequent period, only 43 errors were reported (32 per year) despite a

Key messages

- Medication errors are uncommon
- There is a need to change the culture towards recognising and acknowledging clinical errors, including drug errors
- Careful review of errors highlights many opportunities for change to make drug errors less likely

gradual shift from medical to nursing administration of intravenous drugs.

The error report form was modified in February 1996 to appear less punitive in order to encourage those responsible to reflect on why the error occurred and how it might have been prevented. In addition, a quarterly feedback session on errors occurring during the previous three months was instituted. Following these changes the reported errors rose from 32.7 to 38 per year (60 errors in the 22 month period before and 135 errors in the 43 months after).

Errors involving morphine sulphate are potentially lethal in paediatrics. Five such errors occurred before July 1998, leading to a number of changes being instituted. Prior to this date, 10 mg, 15 mg, and 30 mg ampoules were available. In one case ampoules had been confused, resulting in the wrong dose being given. At this time, it was decided that only the 10 mg ampoule strength would be stocked. The NICU changed to using syringes of morphine preconstituted by pharmacy staff, at a concentration of 50 µg/ml. In addition, all morphine constitution and administration had to be checked by two people. There have been no further errors involving morphine reported to date.

Discussion

In this study, we reviewed five years of medication errors, reporting data from a large UK children's hospital. A total of 195 errors were reported at a rate of 0.15% of admissions (one error per 662 admissions) or 0.51 per 1000 bed days (one error per 1976 bed days). This rate is low compared to most published figures. Adverse drug events in 3.7–17% of admissions have been reported in hospitalised adult patients in the United States.^{3–6} Most published data relate to all adverse drug events, including incidents such as side effects and potential drug errors. It is recognised that somewhere between one fifth and one quarter of errors may be intercepted and corrected before any drugs are administered to patients.^{3 15 16}

There is little data on errors in children in hospital. Raju *et al* reported iatrogenic medication error rates of 14.7% of all admissions to a PICU and NICU over a four year period,¹² while Vincer *et al* found 13.4 incidents per 1000 patient days over two years in a NICU.¹⁴ In contrast, in a paediatric emergency department treating 55 000 children annually, Selbst *et al* found only 33 medication incidents in five years.¹³

These variations in error reporting rates highlight the difficulties in making valid comparisons of reported error rates between studies. Such difficulties have been highlighted in previous studies.² Some of the points made are worth stressing. Our reporting system was mandatory. Leape *et al* emphasised the influence that fear of punishment may have on error reporting and the improvement that may follow if immunity from disciplinary action is offered.⁸ Similarly, we observed an increase in error reporting after system changes which decreased punitive aspects and encouraged reflection on the cause of errors. Vincer *et al* also reported a substantial increase in the reporting of medication incidents after a change to a less punitive system.¹⁴ It should, however, be recognised that voluntary systems may also detect only a fraction of medication errors.¹⁷ The intensity of the search for errors is also likely to have an effect. Other studies have used much more intensive case finding mechanisms.³ Our study looked at data from a routine reporting system and did not make any additional effort to detect errors.

Although the rate of reported error was low, many of the errors were similar to those found in other studies. Most errors occurred in the medical wards where the majority of drugs are administered. Nurses reported more errors than any other health care professional, in keeping with previous data.¹²⁻¹⁵ In our hospital, this partly reflects the fact that nurses are increasingly responsible for giving all medications, precisely because they have better error trapping systems in place. The types of error and the drugs involved were also similar to previous studies.^{12-14, 18}

A type of error that may be particularly important in children is that caused by tenfold errors. We found 8% of the reported errors were of this type. The importance of checking calculations and of avoiding decimal points where possible has been emphasised.¹⁹⁻²⁰

In 48% of cases parents were not informed. We thought this figure was high. Selbst *et al* reported that one third of families were not made aware of the error.¹⁵ The reporting form used in this study asks if parents were notified, and if not, to specify a reason. In many cases the comment was that it was felt inappropriate to notify, for example, pharmacy labelling errors identified prior to the drug being given. In other cases, the reasons given included the fact that the child came to no harm, or that the parents were not readily available at the time and to raise the error subsequently was thought likely to cause undue stress.

Virtually all the publications on medication errors identify opportunities for systematic changes to reduce the risk of future errors. All too often, the prevalent culture is one of blame and punishment. Our finding that 96% of reported errors were classified as minor while 9.2% required active intervention may perhaps be interpreted as in keeping with downplaying incidents as a result of fear of subsequent repercussions. The consequent reluctance to acknowledge errors openly may result in system failures being missed.

Most errors are not a result of individual negligence but arise more from systemic organisational failures. Leape *et al* have emphasised the importance of a systems based approach where the emphasis shifts from the individual making the error to the characteristics of the system within which they function.⁸ We found a number of examples where focusing on understanding why errors occurred provided opportunities for change to make errors less likely in the future. The importance of hospital wide standardisation is well illustrated by our experience with morphine sulphate. Our failure to reduce and standardise the number of intravenous syringe pumps in use can only give cause for concern.

The medical profession in the UK has come rather late to admitting openly that adverse medical incidents including medication errors are an important problem. But it is likely that only by understanding and modifying the underlying causes will we be able to reduce future errors. Our own experience suggests that opportunities for improvement are not difficult to find in paediatric practice.

JYP suggested the idea for the paper. JW established and maintains the reporting system. LR collected the data, performed the data analysis, and wrote the first draft. LR and JYP prepared the final draft which all authors reviewed and approved. LR and JYP are the guarantors for the paper.

Appendix

Types of medication error requiring to be reported in RHSC, Glasgow

- The *wrong medicine* is given
- The *wrong dose* of medicine is given
- Medication is given in the wrong concentration, in the wrong fluid, or at the wrong rate (*wrong preparation*)
- Medicine is administered significantly outwith the prescribed timeframe when there are no extenuating circumstances (*wrong time*)
- *Wrong route* of administration is used
- Medication prescribed is likely to produce a known allergic reaction (*risk of allergic reaction*)
- Medication is given but not prescribed (*unauthorised drug*), or prescribed but not given (*omission*)
- The medication is given to the *wrong person* (*unauthorised drug*)
- Dispensed medicine is labelled wrongly (*wrong labelling*)
- Wrong medicine or strength of medicine is dispensed for the patient's use at home (*wrong dispensing*)
- Any of the above occurs with radiological contrast medium.

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Commentary

SIZE OF THE PROBLEM

Ross and colleagues describe one medication error (the wrong medicine, the wrong dose, the wrong preparation, the wrong route, the wrong time, or to someone known to be allergic) for every 660 admissions. Ten per cent required an intervention and one “medium/serious” error (clinical deterioration) occurred every 13 000 admissions. There were 1 104 958 admissions aged 0–15 years in one year in England.¹ Thus, one would expect at least 1675 avoidable medication errors occur per year in paediatric inpatients in England, of which 85 are moderate/severe reactions. The numbers are probably higher. The authors discuss why a voluntary and punitive system is likely to lead to under reporting, particularly for drugs prescribed unlicensed or off label.² Moreover, the audit is confined to inpatients. In my hospital,³ medical outpatients outnumber inpatients by over 3:1 and children attending A&E with medical problems and not admitted outnumber those admitted by over 3:1.

COST

There were no deaths attributable to medication errors in the Scottish study but deaths do occur and receive wide media coverage and undermine public confidence. Over a six year period, errors in prescribing, monitoring or administering drugs accounted for 25% of settled medical negligence claims against general practitioners.⁴

WHAT CAN THE INDIVIDUAL DO?

The following should help to avoid medication errors.^{5 6 7}

- Avoid decimal points
- If decimals are unavoidable, use a leading zero before the decimal point; avoid trailing zeroes after the decimal point
- Spell micrograms and nanograms in full
- Avoid abbreviations

- Doctors with poor handwriting should print prescriptions
- Do not prescribe or prepare drugs in the middle of the ward round—retire to a quiet dedicated area and check all calculations with a calculator.
- Follow your local code of practice.⁸

HOW CAN WE CHANGE THE ORGANISATION?

Differing infusion pumps cause confusion. Errors appeared to increase when the service was busiest. During an audit in Nottingham, 20 neonatal drug checks were observed during which there were 57 interruptions by other staff or alarms.⁹ Prescriptions and calculations should be double checked (30% were not in the study of Ross *et al*). Errors appeared to decrease after increased training was provided, although this is always open to confounding in an uncontrolled longitudinal study. Parents must be told about medication errors (only 48% were informed in this study).

WILL MEDICINES FOR CHILDREN HELP?

The fewer calculations the better (five of the incidents involving a tenfold error were a result of miscalculation). *Medicines for children*⁶ simplifies paediatric dosing by using standardised age bands agreed throughout the European Union.¹⁰ The formulary uses mg/kg or µg/kg doses throughout and gives the individual dose and frequency rather than the “total daily dose” which then requires another calculation.

THE FUTURE

A dosing or concentration mistake accounted for 40% of the errors. The provision of drugs in appropriate concentrations and formulations would help avoid some of these errors and the Medicines Control Agency is aware of this. A centralised intravenous administration service (CIVAS—all intravenous prescriptions are calculated and constituted by a pharmacist) operates in one of the Nottingham hospitals during “office hours”. A recent consultation document recommended that traditional working practices need to be modified to provide a quality service at all hours¹¹ and recognised that the “demand for pharmacists to support the developing prescribing and medicines management agenda continues to grow”. Automatic computerised linkage of medical records would guarantee that if one doctor is told a child is allergic to a drug, this is highlighted automatically on all other health records. Pocket PCs give internet access and the capacity to store 10 books on a hand held device weighing 200 g. All children's drug doses could be calculated using software for automatically checking the prescription. However, the handwriting recognition software may still struggle with doctors' notorious scripts.^{12 13}

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Prognosis after seizures

It has long been held, almost as an axiom, that one seizure is not epilepsy but two or more are. For this definition of epilepsy to have any real practical importance it must be shown that the implications of multiple seizures are significantly different from those of a single seizure. A long term follow up study of children in New York has supported this definition (Shlomo Shinnar and colleagues. *Annals of Neurology* 2000;48:140–7).

The study included 407 children who presented with a first, unprovoked seizure between October 1983 and August 1992. Mean age at first seizure was 6.8 years and mean period of follow up was 9.6 years. The seizures were classified as cryptogenic/idiopathic (342 children) or remote symptomatic (static encephalopathy, or previous brain insult; 65 children). The cumulative risk of a second seizure at one, two, five, and 10 years after the first was 29%, 37%, 43%, and 46%. After a second seizure 72% had a third, 58% had a fourth, and 29% had a total of ten or more seizures. The cumulative risk of a third seizure at one, two, and five years after a second was 57%, 63%, and 71%. Aetiological classification was an important determinant of recurrence risk. In the cryptogenic/idiopathic group 60% had no recurrence, 13% had one recurrence, and 10% had nine or more recurrences. In the remote symptomatic group the corresponding figures were 28%, 8%, and 32%. An abnormal EEG after a first seizure increased the risk of having a second. Early recurrence (within 6 months) increased the risk of further recurrences over the first year. Anticonvulsant treatment halved the risk of recurrence but only in the first three months, and it did not influence the risk of having many (nine or more) recurrences.

In neurologically normal children there is a 60% probability that a single unprovoked seizure will be an isolated event. After a second seizure the probability of having no more falls to 28%. Of children with a neurological deficit 72% will have at least one recurrence after a first unprovoked seizure. Treatment may not prevent multiple recurrences. The authors of this study conclude that treatment “suppresses seizures but does not alter the underlying course of the illness”.

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