Medication errors in a children's hospital

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Objectives: **This study aimed to identify medication errors occurring and develop methods to reduce the risk of their recurrence in neonatal and paediatric patients.**

Methods: **Data collection of pharmacist and nurse interventions on prescriptions containing errors, prescription chart review and observations of drug administration, were all done over a six week period in a 92 bed children's hospital in the Midlands area of the UK. Errors and violations of procedure in drug prescribing and administration were identified in order to find ways to avoid them in future.**

Results: **Interventions to correct or clarify prescriptions were made on 139 prescriptions by pharmacists and nurses. Three 10-fold errors were intercepted before reaching the patient. Common prescribing problems documented during chart review included the areas of allergy documentation, unsafe discontinuing and alteration of prescriptions, unclear writing and signing of prescriptions. Drug administration was observed in 253 patients. 642 oral and 110 intravenous drug administrations were observed. Actual errors were observed in nine cases (1.2% administrations), and violations of procedure in 141 (19%). Risk areas identified included failure to follow double checking and patient identity checking procedures, poor administration technique in the areas of inhaled/nebulised therapy, IV drugs and oral/gastrostomy drugs and poor documentation.**

Conclusion: **This study illustrates areas where children are vulnerable due to medication errors, and potential errors due to violations of hospital procedures. Recommendations for means to address these issues are made.**

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Introduction

Most drugs are prescribed, dispensed and administered safely and effectively. However, since humans are involved there is a risk of error, and mistakes occasionally occur. Errors that result in serious harm to patients are distressing, not just for the individual or family affected but

also for the staff and organisations associated with the error[1]. Errors may occur on a repeated basis without the organisation learning from the error. Such errors have attracted high levels of attention and a number of policy documents have been published[1-4]. In the UK the National Patient Safety Agency (NPSA) was established to improve the safety and quality of care through reporting, analysing and learning from adverse incidents and 'near misses'. Medication errors can occur in any area of patient care and most research in this area has been done in adults. Children, however, may be at three times greater risk of medication errors compared to adults[5]. Reasons include the need to calculate doses on an individual basis based on age; weight; surface area; constantly changing pharmacokinetics and pharmacodynamics affecting ability to handle and respond to drugs; limited availability of prescribing information for many drugs and the need to use unlicensed and off label drugs due to the lack of availability of suitable products for children. These factors lead to the need for complex calculations and manipulations; 10, 100 and 1000 fold errors have occurred with devastating consequences[6,7].

There is limited information regarding paediatric medication errors in the UK and Europe. One estimate suggests that at least 1675 avoidable medication errors occur annually in paediatric inpatients in England, of which 85 are likely to be moderate or severe[8,9]. This estimate used a study relying on spontaneous reporting of errors, a method notorious for under-reporting, therefore the actual numbers are likely to be far higher. In eight years at least 29 children died in the UK alone[6]. The UK National Service Framework for Children, Young People and Maternity Services highlighted that errors in prescribing and administration of medicines to children are at least as common as in adults and that their consequences can be more serious[10].

It is recognised that the use of medicines, types of errors occurring in children and therefore interventions to prevent errors are different from adult patients[11]. Many studies have reported error numbers or rates but few have identified effective error prevention strategies. This study aimed to identify medication errors occurring in a children's hospital and develop methods to reduce the risk of their recurrence.

Methods

The study was approved by the Derbyshire Research Ethics Committee. Three methods of data collection were used since it is recognised that different methods each have their own advantages and limitations[12]. These included collection of nurse and pharmacist clinical intervention data, prescription chart review, and observational studies of drug administration.

The following areas were studied in the Derbyshire Children's Hospital, a hospital with 92 beds in the Midlands area of the UK. Data were collected over a six week period in paediatric medical and surgical wards, paediatric intensive care unit (PICU), neonatal intensive care unit (NICU) and the emergency department. Medicines for children in this hospital are prescribed mainly by junior and middle grade paediatric doctors, although some prescribing is done by paediatric consultants and also adult-based surgeons and anaesthetists. Administration of prescribed drugs is done by qualified paediatric nursing staff and a policy for double checking the administration of all children's medicines operates in the hospital. A paediatric clinical pharmacist visits the ward each day (Monday to Friday) to review all children's prescriptions, supply in-patient and discharge medicines and provide advice and drug information.

Discussion groups were held with medical, pharmacy and nursing staff to inform them about the study prior to data collection starting. It was stressed that processes would be examined, not individuals and that all data collected would be anonymous. A letter was sent to all members of staff to inform anyone who could not attend a discussion group.

Interventions

Nurses and pharmacy staff were asked to document all interventions made in all clinical areas in Derbyshire Children's Hospital during the course of the study period. Pharmacists carried a data collection form on ward visits and copies were also available in the dispensary. Nursing staff used a form attached to the drug trolley. An intervention was considered to be the need to contact a doctor to clarify or change a prescription when an error (e.g. incorrect dose) or potential for error (e.g. an unclear prescription) was detected.

Prescription chart review

Prescription charts in all areas were examined and a data collection sheet used to assess compliance with hospital standards for prescribing. Clarity of prescriptions was assessed rather than clinical accuracy of drug dosing regimens, which was evaluated using data collected on pharmacist and nurse interventions. Data analysis was performed using an Access database.

Observational studies

A paediatric clinical pharmacist and a senior pharmacy technician both experienced in observational studies of medicines administration and error detection accompanied nurses on their drug administration rounds (Monday to Friday, usually two medicine rounds daily). Actual errors (preventable events that may cause or lead to inappropriate medication use or patient harm) and violations of procedure (deviations from hospital procedures) were recorded in detail. Most drug administration rounds observed were 0800 and 1200 rounds since these were the busiest times for drug administration. Some 1800 and 2200 rounds were also observed as were a number of administrations outside drug rounds.

If an error was identified, it was prevented from reaching the patient by the observer alerting the nurse in a discreet manner without distressing the nurse or making the patient or carers aware.

Results

Interventions

A total of 139 clinical interventions to correct or clarify prescriptions were documented over the six week study period. 98 interventions were recorded by pharmacists visiting wards and by dispensary pharmacists and all were accepted by the prescriber (Table 1). It is not known how many drug doses reached the patient prior to pharmacist intervention, however no reports of patient harm were made.

Three 10-fold errors were all intercepted by a pharmacist before dispensing or administration:

- Thyroxine 0.25 mg prescribed instead of 25 microgram
- DDAVP injection 15 ml prescribed instead of 1.5 ml
- Folic acid 100 mg prescribed instead of 100 microgram (1000-fold error)

Forty-one interventions were recorded by nursing staff and accepted by the prescriber (Table 2). Dosing errors were a common prescribing error intercepted by nurses and generally were detected before the patient received a dose.

Other common prescribing problems documented during detailed review of 123 prescription charts (586 prescriptions) included the areas of allergy documentation, unsafe discontinuing and alteration of prescriptions, incomplete, unclear and ambiguous writing and signing of prescriptions (Table 3).

Drug administration errors

Drug administration was observed in 253 patients. 642 oral and 110 intravenous (IV) drug administrations were observed. Actual errors were observed in nine cases (1.2% administrations), and violations of procedure in 141 (19%) (Table 4).

Interruptions

In addition to the errors and violations documented above, 63 interruptions were observed on drug administration rounds (8.4% actual drug administrations). These happened in all areas but were a particular issue on the NICU where 13 out of 14 (93%) observed drug administrations were interrupted, mainly by other members of the unit staff.

Discussion

This study documented errors and procedure violations in prescribing, dispensing and adminis-

Table 1 Interventions recorded by pharmacists

	Errors	
	Actual	Potential
Dose too low	20	0
Dose too high	9	0
Dose change to make measurable	0	6
10-fold errors	3	0
Incorrect dose	***32***	***6***
Allergy information not completed	15	0
Drug omission from prescription	11	0
Incorrect frequency of doses	10	0
Inappropriate timings of doses	10	0
Unclear prescription	0	5
Advice on drug selection	0	4
Not signed	2	0
Wrong strength of infusion	1	0
Discontinue electrolyte supplement	0	1
Two prescription charts – one patient	0	1
Total	**81**	**17**

Table 2 Interventions recorded by nursing staff

	Errors	
	Actual	Potential
Incorrect dose	7	0
No date	7	0
Incorrect frequency	5	0
No flush of saline prescribed	0	5
Inappropriate timing of dosing intervals	4	0
Incorrect route of administration	3	0
Unclear/illegible prescriptions	1	2
No prescribed dose	2	0
Incorrect IV fluid prescription	1	0
Paracetamol prescribed regularly and as required	1	0
Wrong drug prescribed	1	0
No patient label on drug chart	1	0
Incorrect strength labelled by Pharmacy	1	0
Total	**34**	**7**

Table 3 Prescribing errors and problems found on chart review (n = 123 charts, 586 prescriptions)

Area of prescribing	Hospital standard	Observed
Allergy information	Signed documentation of patients' allergy status on all treatment charts.	42 charts with non-approved abbreviations e.g. 'NKDA' (no known drug allergies). All allergies, including foods etc, should be documented therefore the words 'None known' should be used. 77 charts incomplete or unclear information 1 patient received a medicine which his chart stated that he was allergic to (suffered no reaction).
Discontinuing prescriptions	A bold, diagonal line drawn across prescription, signed and dated	Incorrect or incomplete in 86 out of 112 (77%) discontinuations
Altered prescriptions	Prescriptions to be rewritten not altered	19 out of 27 (70%) altered prescriptions were not rewritten.
Signatures	Doctors should sign clearly or print their name underneath their signature	523 of 592 (88%) signatures illegible.
Abbreviations	Only approved abbreviations to be used	62 prescriptions with non-approved abbreviations e.g. mcg (microgram), ° (hourly), codeine phos, N saline, U (units)
Dose clarity	Doses should be clear and unambiguous	Poor clarity of dose in 123 prescriptions (21%) e.g. cyclizine 25-50 mg; codeine phosphate 30-60 mg; pethidine 25-50 mg.
Route clarity	Prescribed routes should be clear and one route per prescription	35 prescriptions multiple routes prescribed e.g. paracetamol o/pr; ondansetron iv/o; cyclizine po/iv/sc.
Frequency recording	Prescribed frequency should be clear and unambiguous	55 prescriptions with frequencies of drug administration poorly prescribed if at all e.g. no maximum doses for 'as required' prescriptions, illegible special directions and times.

tration of drugs in a children's hospital. While it is appreciated that errors happen wherever humans are involved such a level of procedure violations with their potential to lead to error and patient harm is of concern.

Prescribing errors

Dose corrections made up the majority of pharmacist and nurse prescribing interventions followed by clarification of incomplete prescriptions. Many were for doses which were too low or too high. Similar findings have been previously documented [13]. Both 10 and 1000 fold prescribing errors occurred. These fortunately were detected and corrected by pharmacists prior to being administered to patients. The complex calculations needed in neonatal and paediatric prescribing and drug administration are compounded by the need to use small volumes of adult formulations. Often the 10 or greater fold error is contained in a volume small enough not to alert the practitioner[14]. The use of decimal points without a preceding zero e.g., .1 instead of 0.1, and the use of trailing zeroes e.g. 1.0 mg instead of 1 mg have also been implicated[15]. Two examples of this were seen in our study on the NICU where caffeine 14.0 mg and gentamicin 5.0 mg had been prescribed which could have been misread as 140 mg and 50 mg respectively (both clarified by pharmacist). The presence of multiple zeroes in the dose is another common contributing cause to tenfold errors together with expression or conversion of units of measure[15]. Levothyroxine was the drug involved in 19% of tenfold prescribing errors in one study and was also seen in our own study[15].

The role of the pharmacist and nursing staff in the detection of errors and protection of patients is clearly highlighted in our study and has been previously recognised[5,11]. In normal daily practice interventions often go unacknowledged and undocumented[16]. Feedback to doctors showed a lack of awareness of the number and type of interventions regularly being made by pharmacists and nurses, and also of the requirements of hospital standards for good prescribing practice. This may reflect a lack of importance attached by medical staff to the task of prescribing[16]. There is also confusion in some doctor's minds as to who takes responsibility for prescribing when a junior doctor prescribes a drug requested by his consultant even when they are left to identify the dose[16]. Some doctors admit to relying on pharmacists and nurses to pick up their errors and therefore not bothering to check doses in reference sources[16].

Other common prescribing errors included poor allergy documentation, unclear discontinuation of prescriptions, altering prescriptions, signing prescriptions illegibly and unclear prescribing of dose, route and frequencies. Such errors have also been shown to be common in paediatric hospitals in the US, though transcription errors which were common in the US were not seen in our own study reflecting differences in medicines management processes[17]. These errors were particularly common on the surgical ward, probably reflecting the high number of non-paediatric prescribers on this ward. This ward also received very limited clinical pharmacy input due to lack of resources which meant that such errors and poor prescribing practice were less likely to be identified and corrected.

Table 4 Problems in drug administration

Administration area	Hospital standard	Errors observed	Violations observed
Double checking	All parts of the drug administration process should be checked from start to finish		Not done on 41 occasions (16% patients) Cursory second checks of oral drug volumes and IV infusions on 7 occasions Independent checking of calculations not obvious on 6 occasions Student nurses allowed to administer medicines to patients unsupervised on 3 occasions
Patient ID	All patients should wear a name band Identity should be checked by comparing this to treatment card by 2 nurses		7 patients (2.8%) not wearing name band (2 pre-verbal and carer non-English speaking) Not done on 28 occasions (11% patients)
Inhalers/nebulisers administration	Administration should follow manufacturer's instructions	5 errors Poor inhaler technique × 3 Nebuliser delivered in volume of 1 ml without dilution Salbutamol nebuliser given 1.25 hours after prescribed time	
IV drug administration	Hospital policies on aseptic technique and safe IV drug administration	IV antibiotic infusion connected to patient, nurse left room without starting pump	IV entry sites not visible when administering drugs (hidden under bandage) × 3 Bolus dose of antibiotic administered too fast × 2 Infusion administered using part-used bag hanging on drip stand. Potentially contaminated end of infusion set connected directly to the patient's IV access Poor aseptic technique × 2
Oral/gastrostomy drug administration	Hospital policies on safe oral/ gastrostomy drug administration	Patient due dose at 1200, nurse about to administer at 0825 Clobazam tablet required halving, tablet shattered, approximately half resulting debris administered (inaccurate dose), × 2	3 oral medicines measured in oral syringes, transferred to medicine pot then drawn up in IV syringe as oral syringe did not fit gastrostomy tube
Documentation	Doses not given should have reason code entered on chart and documented in nursing Cardex. Drugs given under Patient Group Directives (procedure allowing nurses to administer certain drugs without doctor's prescription) should be entered on appropriate section of chart		38 occasions, doses not given as patient asleep (13), refused (4), in bath (1), not needed (3), no reason obvious (17). Treatment cards left blank or had 'O' written with reason undocumented. Rarely documented, therefore no record of administration made in most cases.

The prescription chart used by our hospital was the same chart used for adults and children. Its lack of suitability for children was highlighted by the study. Many alterations needed to be made to change pre-printed drug administration times, which were geared towards nurse drug administration round times for adult patients, and were unsuitable for child-friendly care. Such alterations made charts messy and unclear, increasing potential for errors. Movement of doctors between neighbouring cities with hospitals using different drug charts also led to prescribing of drugs on the wrong area of the chart. One national standardised paediatric drug chart would avoid these issues. However, with the impending introduction of electronic prescribing it is unlikely that the time and resources required to gain agreement on such a chart is likely to be worthwhile.

It is hoped that electronic prescribing systems will eliminate these problems and such systems have been suggested to be the answer to many causes of error[11]. Sophisticated systems contain clinical decision support systems such as patient allergy alerts and suggestions for drug doses and frequencies[11]. If these are successfully introduced they should address many of the prescribing errors noted in our study. Unfortunately, it is still likely to be a number of years before they are used routinely in all hospitals in the UK and operate at a level to reduce risks in prescribing to the high degree suggested by some studies[11]. It is also recognised that although the overall rate of errors is likely to be reduced by the introduction of electronic prescribing, new errors such as typographical errors where the wrong button is pressed are likely to emerge[11].

The use of non-standard abbreviations as seen in our study has resulted in errors[18]. The use of U instead of units has led to 10-fold errors when it has been confused with a 0, e.g. 10,000 units of heparin have been administered instead of 1000[1].

Examples of this poor prescribing practice were seen in our study particularly associated with insulin which has also been associated with 10-fold overdose.

A number of prescriptions included dose ranges instead of a specific dose calculated for each child e.g. codeine phosphate 30–60 mg. This was common on the surgical ward and probably reflects adult practice. Dose ranges should not be used in paediatric patients, the actual required dose should be calculated using a recommended reference source such as the British National Formulary for Children[19]. Small children given doses at the top end of ranges such as those documented in our study were likely to receive inappropriately large doses. The practice of prescribing drugs by multiple routes on one prescription, e.g. po/pr was also inappropriate. Some drugs (e.g. paracetamol, prochlorperazine) require different doses for different routes of administration due to changes in bioavailability. There was also little room on the treatment chart for the actual route used to be documented by nurses. Again, there was a role for the clinical pharmacist on this surgical ward which at the time of study was not being provided.

Administration errors

The hospital introduced double checking of all steps relating to medicines administration subsequent to a public enquiry where children had been murdered in a hospital by a nurse using drugs including insulin[20]. Double checking aimed to minimise the risk of any individual tampering with medicines and causing patient harm and also to reduce errors. Double checking of the prescription, drug selection, dose calculation and dose measurement were generally well done by nurses in our study. Double checking of patient ID and drug administration however rarely happened. Double checking was observed to range from a thorough check by some, to a token gesture by others. Some consider that having a second checker makes the lead nurse less careful as they expect the checker to pick up mistakes. It has been suggested that the second checker plays only a minor role in the identification of prescribing errors on prescriptions and may not justify the expense involved[21]. Further research is needed in this area particularly in paediatrics where many centres invest resources in this process without firm evidence to support or reject it.

Administration of drugs to the incorrect patient has been shown to be a common error[22]. The lack of adherence to the hospital patient ID policy seen in our study is therefore of great concern since the two are frequently linked[22]. Nurses themselves have suggested failure to check a patient's wristband with the prescription chart as being the most important reason why drug errors occur[22]. In the USA, automated dispensing devices linked to other technologies such as bar coded patients are an effort to reduce this source of error. Such innovations are likely to be a long way off in the UK[23].

Errors in the preparation and administration of 49% of IV drug doses have been observed in other studies and are highlighted to be a potential source of serious harm for patients[24]. Centralised preparation of IV drugs by pharmacy has been suggested to be a means of minimising risk[10]. Our hospital is fortunate in having this service available for most IV doses, including a 24 hour service for high risk drugs. No errors in making up IV drugs were observed in our study, illustrating the benefits of this service. Violations of aseptic procedures were noted however, and may put patients at risk of infection.

The observed use of IV syringes to administer oral medicines through gastrostomy lines is worrying. Inappropriate syringe use has allowed the administration of oral medicines via the IV route in a number of patients and fatalities have resulted[25-27]. This is a highly topical issue which is being addressed in the UK by the NPSA.

Extra doses being administered are a common source of administration error. Poor documentation, as seen in our study where omitted doses or doses given under a patient group direction were not correctly recorded, if at all, has been recognised to exacerbate this risk[22,28]. Interruptions were also a common occurrence during drug administration. Nurses have cited being distracted by patients and other events on the ward as being a major cause of drug errors[21]. In our own study nurses themselves were the source of the majority of interruptions, particularly in the NICU where complex calculations and drug manipulations are constantly required.

Recommendations

In light of the errors and procedure violations commonly seen in our study, the following recommendations were made to attempt to reduce the risk of them happening again and particularly to avoid patient harm.

- Redesign the drug chart to make it more appropriate for paediatric prescribing:
  - space for a double signature/check box for both nurses involved in drug administration to sign

  - no pre-printed administration times, drugs and times to be prescribed individually for each child
  - more space for prescribers to write clearly without abbreviation
- Reinforcement of double checking procedures
- Reinforcement of the importance of checking patient ID in accordance with hospital policy
- Nurse training sessions to address
  - aseptic technique and administration of IV drugs
  - use of inhaler devices
  - administration through gastrostomy sites
  - documentation of missed doses
  - administration of drugs by patient group direction
- Protected nurse time for drug administration to minimise interruptions
- Training sessions on good paediatric prescribing practice at doctors induction days emphasising the areas of poor practice highlighted by the study
- Pharmacy service to surgical ward to be improved

The above measures have been implemented to address the areas of risk raised by this study through hospital clinical governance and risk management processes. The new prescription chart is easier to use and facilitates clear prescribing and reinforces double checking procedures by providing more room for both nurses involved in the process to sign. Despite there previously being procedures governing drug prescribing, dispensing and administration, not all professionals were familiar with them. A review took place regarding these policies and resulted in ensuring that all staff had time to read them as part of their induction. A robust multi-professional medication action plan was developed with identified leads and timeframes to address the gaps that existed. A shared governance approach was used to engage all grades of pharmacy, nursing and medical staff with this action plan. This facilitated good reporting of medication errors and has seen an increase in near miss reporting allowing constant review and update of practice. Further studies are planned to assess the impact of the introduction of these measures on error rates and types.

Conclusions

This study illustrates areas where children are vulnerable to medication errors, where violations in practice are most likely so increasing the risk and where risk reduction strategies can be introduced. The resulting work helps to meet national insurance standards and to reduce risks and annual premiums for the hospital but most importantly protects the patients in the hospital.

Limitations of study

Patient numbers were low as the study was conducted during the summer when the wards are less busy. In busy periods with greater demands on staff the situation may be worse than identified here since workload is frequently cited as a contributory factor to medication errors by nursing and medical staff[21].

The interventions section of the study relied on nurses and pharmacists completing forms to report these. This probably, therefore, is an under-estimate of the numbers of interventions actually being made. However, as can be seen, significant numbers of interventions were made during this relatively short, but intensive study period and should be a good reflection of the types of errors and problems being identified and addressed by these personnel. The total number of drugs prescribed over the 6 week study period is not known, therefore one cannot calculate the incidence of prescribing errors.

As highlighted, certain prescribing errors were common in areas where medical staff more used to dealing with adult patients needed to prescribe for children. The differences in error rates between paediatricians and these doctors were not studied in more detail but would be an interesting area to examine in the future.

An undisguised observational technique of drug administration was used. This may have potential effects on the behaviour of the staff being observed. However, great lengths were taken using discussion groups prior to study initiation to inform all staff that the study would examine processes not individuals and would be anonymous. Observation was well received with a good rapport between observers and nursing staff. Observation was carried out as often as study resources allowed, it is acknowledged that not all drug administration in the study period was seen and consequently some errors or procedure violations may not have been observed.

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Conflict of interests

There were no conflicts of interests for any of the authors involved in this study.

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