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PHARMACIST INTERVENTIONS IN PAEDIATRIC PRESCRIPTIONS: A SIX-MONTH AUDIT

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Abstract

This short review summarises what published studies say about pharmacist interventions on paediatric prescriptions and about the way such interventions are recorded in time-limited audits, and it reports no new data. It describes why children are vulnerable to prescribing errors, the error types most often reported, and the categories of intervention that hospital and community pharmacists make. Methods used to classify, grade and report interventions are compared. Pharmacist review consistently finds and prevents errors, with dose problems dominating, but studies differ in definitions and severity scales, and few follow interventions through to clinical outcomes, which limits comparison between audits.

1. INTRODUCTION

Children are not small adults, and prescribing for them is a different task. Doses are calculated from weight or body surface area, many products are made for adults and must be diluted or divided, and the evidence behind many drugs is thinner than for adult medicine. Studies in hospital wards have found that errors in paediatric prescribing are common, and that a good share of them could have caused harm had they reached the child [1, 2]. A systematic review of medication errors in paediatric care concluded that dosing was the most frequent problem, and that most errors arose at the prescribing stage [3]. The consequences of a slip are also different. A dose that is ten per cent high in an adult is rarely dangerous, whereas the same relative error in a premature infant may be.

A pharmacist is positioned to catch many such problems. Prescriptions in most hospitals pass through the pharmacy before drugs are dispensed, and clinical pharmacists on wards see the chart in context with weight,

renal function and indication. Each time a pharmacist contacts a prescriber to change an order, the event is described as an intervention, and these events are often logged, graded and counted. Periodic audits of the log, for instance over six months, are a common way to show what a pharmacy service contributes [4, 5]. The same checks happen at several points, at the dispensary, on the ward and at discharge, and each gives a separate opportunity to find a problem that an earlier step missed. This layering of defences is the reason pharmacy is regarded as a core safeguard in the medicines pathway.

This review draws on published reviews, trials and observational studies to describe what is known about pharmacist interventions in paediatric prescribing. It does not present an audit of its own. It covers the reasons for vulnerability, the main error types, the structure of intervention programmes and the methods used to record and grade them, and it ends with the limits of the evidence. The aim is to give readers a basis for designing or reading an audit of this kind. Where the studies cited differ in how they define an error or an intervention, the differences are pointed out, since these matter when numbers from separate audits are set side by side. Quoted figures are limited to those that are widely reported.

Community pharmacists also see paediatric prescriptions, though the literature from that setting is smaller. Dispensing checks on dose, formulation and interactions are routine, but the pharmacist often lacks the weight and diagnosis that a ward pharmacist has, which narrows what can be confirmed. Telephone contact with the prescriber is the usual route, and records of what was changed are less consistently kept than in hospital, which limits what can be learnt from them. Studies that link community dispensing data with hospital records could show how errors travel across the boundary.

2. WHY CHILDREN ARE AT RISK

Physiology changes quickly in the first years of life, and so does drug handling. Gastric pH, body water, protein binding, enzyme activity and renal clearance all differ between a neonate, an infant and a school-age child, and they can shift within weeks [6]. A dose that suits a toddler might be toxic in a premature infant. Because of this, doses are scaled by weight or surface area and sometimes by postmenstrual age, which brings arithmetic into every prescription. The wide range of body sizes, from under a kilogram to adult weight, means that the same drug may be given over a hundred-fold range of dose. Even within one age band, illness, malnutrition and organ immaturity can change how a child handles a drug.

Licensing adds a second layer. Many drugs used in children are not licensed for their age group or are used outside the terms of the licence, and surveys across European paediatric wards found that a large proportion of prescriptions fell into these categories [7]. Unlicensed and off-label use has been linked with a higher likelihood of adverse reactions in hospitalised children [8]. It also means that dose information is less standardised, and a prescriber may rely on a formulary, a colleague or memory rather than a product label. For rarer conditions there may be no authorised product at all, so a hospital pharmacy must prepare a special formulation, and the instructions for preparing it become one more place for an error to enter.

Neonates, and particularly premature infants, sit at the extreme end of this vulnerability. Hepatic enzyme systems that metabolise many drugs are immature at birth, glomerular filtration is low, and the blood-brain barrier is more permeable, so drugs and excipients that adults tolerate can accumulate. The old lesson of chloramphenicol toxicity in newborns, in which a dose scaled from adult practice caused circulatory collapse, still illustrates the principle [6]. Excipients such as benzyl alcohol and propylene glycol, harmless at adult exposure, deserve attention in small infants. Prescribers and pharmacists in neonatal units therefore depend on specialist references and unit protocols, and general adult knowledge is not enough to check an order safely [3, 6].

System factors compound the problem. Liquids may be prepared from adult tablets or capsules, concentrations vary between products, and the volumes drawn up are often tiny and measured in fractions of a millilitre.

Each step offers a chance for an arithmetic slip. Nolan's argument for system changes, in which failures arise more often from faulty systems than from individual carelessness, applies well here [9]. Prescribers rotate through paediatric posts quickly, and junior doctors write most orders, so knowledge of unit practice is variable [10]. Reviews of error prevention in children list standardised concentrations and dose-banding among the practical remedies, because they cut the number of calculations needed at the bedside [11].

Children also cannot speak up for themselves. An adult may notice a tablet looks different or question a dose, whereas a baby cannot, and a parent may not know what to expect. This puts more weight on the professionals who check the order and less on the patient as a safety net, a point made in the patient safety literature [12, 13]. Written information for carers and clear labelling of liquid products are partial answers, but the main protection remains the check made by trained staff before the drug is dispensed or given.

3. PRESCRIBING ERRORS IN PAEDIATRIC PRACTICE

A prescribing error is more than a mistake in handwriting. Definitions proposed in the literature stress an unintentional reduction in the probability of treatment being timely and effective or an increase in the risk of harm, and they separate errors of decision from errors of writing the order [14]. Studies using such definitions have reported rates ranging from under one to several errors per hundred orders in children, with the range depending on setting, method of detection and case mix [2, 15]. A large American study of paediatric inpatients found that potential adverse drug events were several times more common than actual ones [1]. The choice of definition therefore determines the headline rate.

The medication process has several stages, and pharmacist review focuses on the first. Prescribing, transcribing, dispensing, administration and monitoring each carry their own error profile. National incident reports show that errors arise at the prescribing, dispensing and administration stages, with some intercepted before they reached the patient, which is the logic behind independent checks [16]. In paediatrics, administration errors are also common, particularly in the preparation of small volumes, so audits restricted to prescriptions see only part of the problem [2, 15]. This is one reason the field takes the systems view promoted by the Institute of Medicine, in which individuals are not blamed for what the system makes easy to get wrong [13].

Dosing problems dominate nearly every dataset. Systematic review found that wrong dose, wrong frequency and wrong rate accounted for most dosing errors, and that infants and neonates were at greatest risk [17]. Tenfold errors, produced by a misplaced decimal point or confusion over units, have been described since the 1980s and remain a persistent hazard [18, 19]. Later series from children's hospitals confirmed that such errors still occur despite awareness and that they are often caught only by a second person [20]. Other recurrent types include omission of information such as weight, incomplete orders, duplicate therapy and interactions. Reviews also point to a lack of weight on the chart, or an out-of-date weight, as a quiet but frequent contributor [3].

The main categories of error and intervention reported in the literature are collected in table 1. Antibiotics, analgesics, anticonvulsants and intravenous fluids and electrolytes feature repeatedly as drug groups involved, which is not surprising given how often they are prescribed and how narrow the safe dose range can be for some of them [11, 21]. Errors that are caught before reaching the child usually go unrecorded unless a pharmacy log is kept, so the true rate of near misses is probably higher than most published figures suggest, since voluntary reporting captures only part of what occurs [16]. Reporting culture also matters. Where staff fear blame, fewer errors are written down, and an apparently low rate may reflect silence and not safety. For this reason, the more reliable estimates come from methods in which trained reviewers go through the chart and compare it with the order, instead of waiting for self-report [15].

Severity matters as much as frequency. Most errors are minor, and a small minority could

have caused serious harm, but the latter are the reason services exist. Scoring methods that grade events from those that never reach the patient to those causing death are well established, and the NCC MERP index is the best known, giving a common language for comparing audits [22]. Others apply a simple three-point scale of minor, moderate and severe potential harm, scored by a pharmacist or a panel [23]. Panels of senior clinicians give more consistent grades than single raters, though they are costly to convene and many audits therefore rely on one pharmacist's judgement.

4. PHARMACIST INTERVENTIONS AND AUDIT METHODS

The evidence that pharmacist involvement helps began with adult intensive care, where participation on ward rounds was associated with a large fall in preventable adverse drug events caused by prescribing [24]. Similar findings were reported in children. Work in paediatric inpatients described unit-based clinical pharmacists preventing serious errors, and earlier studies from children's hospitals had already shown that pharmacists intercepted a meaningful number of prescribing errors [4, 5]. Higher clinical pharmacy staffing in hospitals has also been linked with lower mortality in a large analysis of American data [25]. Not every study found a benefit, and effects tend to be larger where the baseline error rate is high and the pharmacist is physically on the unit.

Table 1: Published evidence on paediatric prescribing errors and pharmacist interventions

Topic	Reported finding	Ref.
Inpatient errors American cohort	Potential adverse drug events were several times more frequent than actual ones.	[1]
Dosing errors systematic review	Wrong dose, frequency and rate were the main types, with infants most at risk.	[3, 17]
Tenfold errors decimal and unit slips	Persistent hazard described from the 1980s and still reported in recent series.	[18, 19, 20]
Off-label and unlicensed use European wards	Large share of paediatric prescriptions outside licence; linked with adverse reactions.	[7, 8]
Risk factors hospitalised children	Age, polypharmacy, off-label use and intravenous route associated with reactions.	[11, 26]
Pharmacist on rounds intensive care	Marked fall in preventable adverse drug events caused by prescribing.	[24]
Unit-based pharmacists paediatric inpatients	Serious errors intercepted and acceptance by prescribers generally high.	[4, 5]
Staffing levels hospital data	Greater clinical pharmacy provision linked with lower mortality.	[25]
Computerised order entry decision support	Fewer serious errors in children; new error types and alert fatigue.	[27, 28, 29]
Severity grading NCC MERP index	Common scale for categorising events from no harm to death.	[22, 23]

A pharmacist intervention can take many forms. The commonest is a dose correction, followed by changes of drug, route, formulation or frequency, requests for missing information, and advice on monitoring or interactions. Others include suggestion of a therapeutic alternative, stopping a drug that is no longer needed, and counselling of carers. These activities fit within the broader philosophy of pharmaceutical care, which holds that the pharmacist shares responsibility for drug therapy outcomes [30]. Whether an intervention is accepted by the prescriber is usually recorded, and acceptance rates in published series are generally high. The mix varies with the unit; surgical wards generate different problems from oncology.

An audit needs a clear plan. Investigators decide on the period, the wards or clinics included, the definition of an intervention and the data fields to be collected: the drug, the problem, the action taken, the prescriber's response and the potential severity. Categorisation of problems may follow a published scheme, and an independent second reviewer improves reliability. Several studies show that without agreed definitions, two pharmacists will classify the same event differently [14]. Counting only interventions that were accepted or only those graded as

significant also changes the headline numbers, and the denominator, whether orders, patients or bed-days, needs to be stated. The spread of the evidence by category is shown in fig. 1. Where possible, the audit protocol should be written before data collection begins.

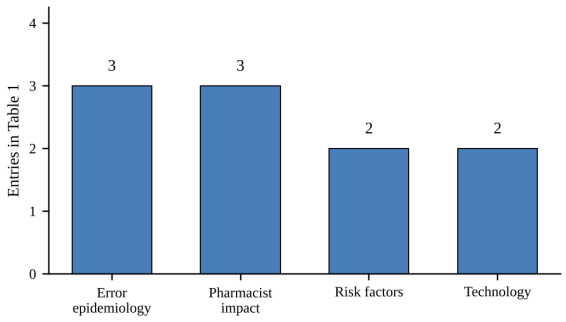


Fig. 1: Number of entries in table 1 by category of evidence

The setting of the pharmacist makes a difference to what is found. A ward-based pharmacist sees the patient, the drug chart and the notes, and can discuss a change straight away, whereas a dispensary pharmacist works from the prescription and whatever else the system displays. Medicines reconciliation at admission and discharge is another area in which pharmacists make interventions, since lists of regular medicines in children are often incomplete or taken from a carer's memory. Early reports from children's hospitals described the activities of clinical pharmacists in these terms, and the pattern has been consistent in later services [5].

A six-month window is a convenient length for an audit because it captures seasonal variation in admissions, such as winter respiratory illness, and the turnover of junior staff. It is still a snapshot. Volumes change with staffing, and the pharmacist's own presence on the ward determines how much is found. Intervention logs reflect what pharmacists notice and choose to record as much as what prescribers get wrong, so a rise in numbers may signal better detection and not worse prescribing [23]. Audit periods that overlap with induction of new trainee doctors often show more errors in the first weeks, and a pharmacist who is new to a ward may also find more simply because every chart is unfamiliar. Reporting the period month by month, instead of as a single total, helps to separate such effects from real change [3].

Electronic systems change both the errors and the interventions. Computerised order entry with decision support has reduced serious errors in children in controlled studies, and systematic reviews of electronic prescribing report similar overall benefits [27, 28, 29]. New error types appear, however, such as defaults that propagate a wrong dose, alert fatigue and unit mix-ups in the interface. Pharmacists in hospitals using such systems spend more time on clinical review and less on transcription, though they still catch problems that the software cannot, such as an unsuitable formulation for a child who cannot swallow tablets. The pharmacist's role therefore shifts towards supervising the system as well as the individual order.

5. CLINICAL AND SERVICE IMPACT

Evidence that interventions improve outcomes is thinner than evidence that they occur. Most studies report intercepted errors and prescriber acceptance, which are process measures. A few estimate averted harm by asking clinicians to rate what would have happened had the intervention not been made, a method that rests on judgement and tends to give high estimates. Direct evidence on length of stay, adverse event rates or readmission in children is limited, although adult studies suggest a benefit [24, 25]. This gap does not mean that interventions are useless. It means that their value is inferred, and the inference deserves some caution. Randomised designs are rare, and cluster trials at ward level would be a feasible next step.

Several risk factors predict where pharmacist attention is best spent. International work in hospitalised children linked adverse reactions with age, the number of drugs, off-label use and intravenous administration [26]. Neonatal and intensive care units, oncology wards and units handling complex infusions have higher error rates per order, so a service with limited staff may do best to focus on these areas. Targeting reduces the number of orders to review while still capturing most of the serious problems, which makes sense when resources are tight [3, 11]. A simple risk screen, applied at the point of prescription verification, can direct limited pharmacist time to the children who most need it, such as those on several drugs, on intravenous

therapy or under one year of age.

Relations with prescribers shape success. Interventions delivered face to face during rounds are more readily accepted than notes left on the chart, and feedback about common errors can reduce their recurrence. A culture in which doctors see pharmacists as colleagues and not as auditors makes the log more complete, because staff report openly. A widely used framework for analysing risk in clinical medicine treats avoidable harm as the product of many contributing factors across the whole medication process, from the task and the team to the patient, and argues that errors reflect weak systems more than careless individuals [12]. Children cross those boundaries often, moving between wards, home and community. Positive relations take time to build, and a pharmacist who is on the ward every day will see more acceptance than one who telephones from the dispensary.

Communication with families is a further contribution that audits of prescription interventions rarely capture. Liquid medicines are easy to mismeasure at home, and carers may stop an antibiotic early or give a dose twice because instructions were unclear. Counselling at discharge, with an oral syringe supplied and the volume marked, is a simple measure that falls within the concept of pharmaceutical care [30]. The same framework counts patient factors among the influences on safe care, and the carer is one layer of defence that children's services have particular reason to strengthen [12]. Counting such activity would give a fuller picture of what a service does.

Cost is rarely examined in children. Intervention programmes require staff time, and justification often relies on estimates of prevented adverse events and the treatment costs avoided. Such estimates are sensitive to the assumptions made, so economic claims need careful reading. A modest saving per prevented event can still be significant across a large service, but studies seldom follow costs prospectively. Studies that report cost per intervention should say whether pharmacist salaries, training and software were included in the calculation. Sensitivity analyses showing how conclusions change with the assumed severity of prevented events are also helpful.

6. LIMITATIONS AND FUTURE DIRECTIONS

The literature has weaknesses that readers of any audit should keep in mind. Definitions of error and intervention differ, severity scales are used inconsistently, and some studies rely on voluntary reporting that undercounts events. Most are single-centre, many are uncontrolled, and few report how often prescribers declined advice or what happened afterwards. Because an intervention is recorded by the pharmacist who made it, there is potential for bias. Results from a teaching hospital in one country may not carry over to a district hospital or a community pharmacy elsewhere [2, 17]. Small samples make rare events impossible to estimate.

Interpretation of a time-limited audit needs care for statistical reasons as well. Attention itself changes behaviour, and prescribers who know their orders are being reviewed may write more carefully, a well-known effect in quality studies. A period of high numbers may be followed by a fall simply because extreme values tend to return towards the average. Without a comparison group or a run of repeated measures, these effects cannot be separated from the effect of the pharmacist, which is why reviews of error-reduction studies urge better designs [3, 31]. Reporting confidence intervals and the proportion of orders actually reviewed would help readers judge how far a number can be trusted.

Improvements would come from agreed core data sets for paediatric interventions, with standard definitions and severity grading, and from independent review of a sample of cases. Linking logs to outcomes such as length of stay would strengthen the case for pharmacy services. Studies in community and primary care would fill a gap in a literature that is dominated by hospitals. Finally, the interaction of pharmacist review with electronic prescribing deserves study, so that the two are designed together and not in competition [27, 28]. Multicentre collaboration would add power and show which findings travel between settings. Qualitative work with prescribers, on why

advice is accepted or declined, would explain much that numbers cannot.

7. CONCLUSION

Published studies agree on the main points. Children are exposed to prescribing errors because their physiology changes with age, because doses are calculated individually and because many drugs are used outside their licence [6, 7, 18]. Dosing problems account for most of what is found, and a pharmacist who reviews orders reliably catches a good share of them before the drug reaches the child [4, 17, 24]. These points hold across hospitals in several countries, which gives them some weight. Such consistency is reassuring.

Where studies disagree, it is mostly over definitions, severity scales and what counts as an intervention, which makes audits hard to compare [14]. Few link interventions to clinical outcomes, and fewer still describe community practice. A six-month audit remains a useful way for a pharmacy to see its own work, provided that the methods are stated clearly, the denominators are reported and the results are read as a description of process, not as proof of benefit [31]. Better shared definitions would do more for the field than additional single-centre counts.

8. ABBREVIATIONS

ADR-Adverse drug reaction, CPOE-Computerised physician order entry, ICU-Intensive care unit, IOM-Institute of Medicine, NCC MERP-National Coordinating Council for Medication Error Reporting and Prevention, NICU-Neonatal intensive care unit, WHO-World Health Organization, ADE-Adverse drug event

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10. AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

11. CONFLICT OF INTERESTS

Declared none

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