Medication errors in paediatric outpatients

Rainu Kaushal,[1,2,3] Donald A Goldmann,[5,6] Carol A Keohane,[4] Erika L Abramson,[1,2] Seth Woolf,[4] Catherine Yoon,[4] Katherine Zigmont,[4] David W Bates[4,7,8]

[1]Department of Medicine, Weill Medical College of Cornell University, New York, USA
[2]Department of Public Health, Weill Medical College of Cornell University, New York, USA
[3]Department of Pediatrics, Weill Medical College of Cornell University, New York, USA
[4]Division of General Internal Medicine, Brigham and Women's Hospital, Boston, Massachusetts, USA
[5]Department of Medicine, Children's Hospital, Boston, Massachusetts, USA
[6]Institute for Healthcare Improvement, Cambridge, Massachusetts, USA
[7]Harvard Medical School, Boston, Massachusetts, USA
[8]Information Systems, Partners Healthcare System, Boston, Massachusetts, USA

Correspondence to
Dr Rainu Kaushal, Departments of Pediatrics and Public Health, Weill Medical College of Cornell University, 402 E 67th Street, Rm LA-261, New York, NY 10065, USA;
rak2007@med.cornell.edu

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ABSTRACT

Background Medication errors are common in many settings and have important ramifications. Although there is growing research on rates and characteristics of medication errors in adult ambulatory settings, less is known about the paediatric ambulatory setting.

Objective To assess medication error rates in paediatric patients in ambulatory settings.

Methods The authors conducted a prospective cohort study of paediatric patients in six outpatient offices in Massachusetts. Data were collected using duplicate prescription review, two parental surveys and chart review. A research nurse classified all medication errors by stage and type of error.

Results The authors identified 1205 medication errors with minimal potential for harm (rate: 68% of patients, 95% CI 64 to 72%; 53% of Rx, 95% CI 50 to 56%) and 464 potentially harmful medication errors (ie, near misses) (rate: 26% of patients, 95% CI 24 to 28%; 21% of Rx, 95% CI 19 to 22%). Overall, 94% of the medication errors with minimal potential for harm and 60% of the near misses occurred at the prescribing stage. The most common types of errors were inappropriate abbreviations followed by dosing errors. The most frequent cause of errors was illegibility.

Conclusion With paper prescribing, half the prescriptions had medication errors, and one in five had a potentially harmful error. These rates are very high. Interventions targeting the ordering and administration stages have the greatest potential benefit.

BACKGROUND

Medical errors are common. Forty per cent of American adults report experiencing a medical error.[1] Medication errors appear to be the most frequent type of medical error. The epidemiology of medication errors in children is less understood.[2] A previous study by the authors found that 5.7% of paediatric inpatients experienced a medication error, and the rate of near misses was three times higher than in adults.[2 3] Factors that make children vulnerable include the need for weight-based dosing, their decreased communication ability and the particular vulnerability of babies with immature renal and hepatic systems.

Most prescription writing occurs in the outpatient setting, and errors in this setting are common.[4 5] A study by the authors found that an adverse drug event (ADE) occurred in 16% of children treated in the outpatient setting.[6] A given patient frequently experienced more than one error or ADE. Most occurred at the administration or ordering stages and were judged to be preventable.

While studies have evaluated harmful errors in the outpatient paediatric setting, little is known about rates of paediatric medication errors without resultant harm.[6]

All medication errors, regardless of whether or not they cause patient harm in a specific instance, are often a part of a cascade of those events that lead to patient harm, and we can identify systematic problems in the medication process through characterisation of these errors. It remains unclear if non-harmful errors are similar to or predictive of potentially harmful errors, and we undertook this epidemiological study to help provide a better understanding of the differences between non-harmful and potentially harmful medication errors. We conducted a multioffice prospective cohort study of paediatric medication errors in the ambulatory setting. We assessed the stages at which medication errors occurred, the types of errors and the types of medications associated with errors.

METHODS

Study sites

We enrolled six paediatric outpatient offices, with two at teaching hospitals, two in urban neighbourhoods and two in affluent suburban areas. During the study period, 132 paediatric healthcare providers prescribed at these practices. All sites were using handwritten prescriptions, which we collected over a consecutive 2-month block at each practice from July 2002 to April 2003.[6]

Definitions

In accordance with the Institute of Medicine definition,[7] medication errors were defined as errors in medication ordering, transcribing, dispensing, administering or monitoring. We further classified medication errors as errors with minimal potential for harm and near misses. For brevity, we refer to medication errors with minimal potential for harm as medication errors throughout this manuscript. An example of a medication error was prescribing a topical cream without specifying the route of administration. Near misses were medication errors with potential for harm that were either intercepted or actually reached the patient and fortuitously did not result in harm. An example was prescribing penicillin for a patient with a known penicillin allergy, but a pharmacist intercepted the prescription. Finally, rule violations were departures from strict standards of prescribing that are nevertheless well understood and were not counted as errors. Rule violations are included in the study because they are not completely appropriate prescriptions, and ideally we hope to eliminate them as well.

Preventable ADEs were medication errors that actually caused harm, while non-preventable ADEs

were those that were not associated with a medication error.[6] We do not report rates of ADEs in this manuscript.

Data collection

Data were collected through a prescription review, telephone survey and chart review. Prescribing information was collected via duplicate prescription pads. A research nurse reviewed all duplicate prescriptions for medication errors. Data collected included medication name, dose, route, category of drug, stage when error occurred and reason for error. This methodology has been previously validated by the investigators.[2 5 8 9] Prescriptions ordered by telephone or facsimile were excluded.

Surveys were used to collect data on medication errors that occurred during the transcribing, dispensing and administration processes. Ten days after the index visit, a researcher conducted a follow-up survey. Participants were questioned about the medications prescribed, potential side effects, method of administration and communication with healthcare providers, along with demographic information. The survey contents and process are further described in an earlier manuscript.[6] Three months after the index visit, research nurses performed office chart reviews to detect evidence of any sequelae from medication errors and adverse drug events.

Inclusion criteria

All prescriptions except non-medication related prescriptions (ie, equipment or formula) were subject to review, but survey participants were subject to inclusion/exclusion criteria. Inclusion criteria included age less than 21 and receipt of at least one prescription at a visit. Each patient could be eligible only once. Exclusion criteria were: patients with second visits or with a sibling already participating in the study to decrease parental survey burden, requests from prescribing physicians to exclude some patients, patients without a working phone, and patients whose parents did not speak English, Spanish or Cambodian. Prescriptions for oral contraceptives, potential treatment of sexually transmitted diseases and equipment were also excluded for patient privacy reasons.[6] Only data from patients who had prescriptions reviewed and participated in the survey were included to ensure completeness of cases.

Classification of errors

We classified all medication errors according to the stage of the medication process during which the error occurred, and by medication category.

Incident classification

Research nurses reviewed all prescriptions for medication errors. Suspected near misses were reviewed by two physicians. Each reviewer independently classified each event as a medication error with minimal potential for harm, near miss, ADE or exclusion, using a rating and classification methodology that has been previously validated.[2 8 9] The physician reviewers then rated each event as to the severity or potential severity of injury to the patient and its preventability. Of note, all medication errors are judged to be preventable. Therefore, all events reported in this manuscript are preventable. The κ statistics for inter-rater reliability were 0.89 for classification of event, 0.75 for severity of event and 0.95 for preventability of event.

Statistical analysis

We report the rates of medication errors per 100 patients and per 100 prescriptions with 95% CIs, and the rates of medication errors according to stage, type and medication category. Illegibility errors were analysed separately. These errors occur very frequently and are easily addressed with very basic prescribing systems. The SAS statistical package was utilised for all analyses (SAS Institute, Cary, North Carolina). This work was approved by the Partners Human Research Committee of the Partners Healthcare System of Boston, Massachusetts, USA.

RESULTS

Providers

In total, 132 paediatric providers participated in the study. Eighty-nine providers (67%) were female (table 1). The mean age was 39.8. Of note, 50% of prescribers were residents, 40% were staff physicians, and 10% were nurse practitioners.

Patients

Thirteen thousand nine hundred and nineteen patients visited participating medical practices, and 3838 (28%) received a prescription. Of those receiving a prescription, 2831 (74%) were eligible for the survey, 328 opted out, and 1782 completed the initial survey (63% response rate). Among participating patients, 2259 prescriptions were written (1.3 prescriptions per patient). Further details of the providers and survey respondents have been previously described.[6]

Rates of medication errors

During the study period, 1669 medication errors were identified in 1782 patients with 2259 prescriptions (74 medication errors per 100 prescriptions). After categorisation of errors, we identified 1205 medication errors with minimal potential for harm and 464 near misses. Of errors with minimal potential for harm, 94% were found by prescription review and 6% were found by survey. Fifty-eight per cent of near misses were found by prescription review, and 42% were found by survey. Of the 1782 patients, 57% experienced at least one error. Among 2259 prescriptions, 57% had at least one error.

Demographic differences in medication error rates

In general, there were very few differences among patients who experienced a medication error a near miss, or neither (table 2). There

Table 1 Characteristics of office practices and healthcare providers

Office practice	Paediatric providers	Staff physicians (n (%))	Residents (n (%))	Nurse practitioners (n (%))	Female (n (%))	Mean years post- training	Mean age
A	7	6 (86)	0 (0)	1 (14)	5 (71)	10.25	40.0
B	11	6 (55)	5 (45)	0 (0)	10 (91)	9.5	36.6
C	88	22 (25)	58 (66)	8 (9)	60 (68)	10.1	34.2
D	9	6 (67)	3 (33)	0 (0)	3 (33)	14.6	36.7
E	11	8 (73)	0 (0)	3 (27)	8 (73)	15.4	46.5
F	6	5 (83)	0 (0)	1 (17)	3 (50)	10.5	45.0
Total	132	53 (40)	66 (50)	13 (10)	89 (67)	11.7	39.8

Table 2 Patient demographics by type of medication error*

	Errors with minimal potential (n (%))	Near misses (n (%))	No error (n (%))	p Value†
Medication errors with minimal potential for harm				
Total	792 (100)	372 (100)	618 (100)	–
Gender				
Female	377 (48)	193 (52)	324 (52)	0.15
Age				
Neonates	14 (2)	8 (2)	27 (4)	0.36
Infants	211 (27)	103 (28)	147 (24)	
Toddlers	244 (31)	122 (33)	181 (29)	
School age	280 (35)	117 (32)	195 (32)	
Adolescents	43 (5)	22 (6)	66 (11)	
Race/ethnicity				
White	394 (51)	168 (47)	294 (49)	0.28
Black	113 (15)	53 (15)	106 (18)	
Hispanic	165 (21)	83 (23)	109 (18)	
Other	103 (13)	52 (15)	91 (16)	
Insurance				
Medicaid	113 (14)	52 (14)	56 (9)	0.008
Non-Medicaid	679 (86)	320 (86)	560 (91)	

*Response rates to survey questions varied between 95 and 100%. Percentages were calculated based on number of respondents to the given question.
†Calculated using χ^2 tests.

was no difference among patients who experienced a near miss. Of note, a given patient frequently experienced more than one error.

Medication errors by stage

The majority of medication errors occurred during the ordering stage. Near misses occurred most often during ordering, followed by the administration stage. Ninety-four per cent of the 1205 medication errors (rate: 50% of Rx; 95% CI 47 to 53%) and 60% of the 464 near misses (rate: 12% of Rx; 95% CI 11 to 14%) occurred at the ordering stage (table 3). Errors during administration represented 23% of near misses (5% of Rx; 95% CI 4 to 6%) but less than 5% of medication errors (3% of Rx; 95% CI 2 to 3%).

Medication errors by type

Among near misses, dosing issues were most frequent and occurred in 8% of patients (95% CI 6 to 9%) (table 3). Other common types of near misses were frequency issues (rate: 3% of patients; 95% CI 2 to 4%) and strength issues (rate: 3% of patients; 95% CI 2 to 4%). Among medication errors, inappropriate abbreviations were most frequent (rate: 20% of patients; 95% CI 18 to 22%), followed by route issues (rate: 13% of patients; 95% CI 11 to 15%), and amount issues (rate: 12% of

Table 3 Rates of medication errors

	n	Percentage	Rate per 100 patients	95% CI*	Rate per 100 prescriptions	95% CI*
Medication errors with minimal potential for harm						
Total	1205	100	67.63	63.87 to 71.51	53.34	50.39 to 56.41
Stage of error						
Ordering	1135	94	63.69	60.06 to 67.47	50.24	47.38 to 53.22
Administering	60	5.0	3.37	2.59 to 4.29	2.66	2.04 to 3.39
Dispensing	5	0.41	0.28	0.10 to 0.60	0.22	0.08 to 0.48
Transcribing	5	0.41	0.28	0.10 to 0.60	0.22	0.08 to 0.48
Type of error						
Inappropriate abbreviation	357	30	20.03	18.03 to 22.18	15.81	14.22 to 17.50
Route issues	231	19	12.96	11.36 to 14.71	10.23	8.96 to 11.60
Amount issues	205	17	11.50	10.00 to 13.15	9.07	7.89 to 10.37
Direction issues	177	15	4.32	3.43 to 5.36	3.41	2.70 to 4.23
Strength issues	121	10	6.79	5.65 to 8.07	5.36	4.46 to 6.37
Dose issues	107	8.9	6.00	4.94 to 7.22	4.74	3.89 to 5.69
Other issues	62	5.2	3.48	2.68 to 4.42	2.74	2.12 to 3.49
Frequency issues	24	2.0	1.35	0.88 to 1.96	1.06	0.69 to 1.55
Duration issues	21	1.7	1.18	0.74 to 1.76	0.93	0.59 to 1.39
Near misses						
Total	464	100	26.04	23.74 to 28.48	20.54	18.73 to 22.47
Stage of error						
Ordering	278	60	15.6	13.8 to 17.5	12.31	10.92 to 13.81
Administering	107	23	6.0	4.9 to 7.2	4.74	3.89 to 5.69
Dispensing	42	9.1	2.4	1.7 to 3.1	1.86	1.35 to 2.48
Transcribing	30	6.5	1.7	1.2 to 2.4	1.33	0.91 to 1.86
Monitoring	1	0.22	0.06	0.003 to 0.25	0.04	0.003 to 0.19
Type of error						
Dose issues	136	29	7.63	6.42 to 8.99	6.02	5.06 to 7.09
Other issues	95	20	5.33	4.33 to 6.48	4.21	3.42 to 5.11
Frequency issues	59	13	3.31	2.54 to 4.23	2.61	2.00 to 3.34
Strength issues	50	11	2.81	2.10 to 3.66	2.21	1.66 to 2.88
Duration issues	50	11	2.81	2.10 to 3.66	2.21	1.66 to 2.88
Direction issues	40	8.6	2.24	1.62 to 3.01	1.77	1.28 to 2.38
Amount issues	21	4.5	1.18	0.74 to 1.76	0.97	0.62 to 1.44
Route issues	12	2.6	0.67	0.36 to 1.13	0.53	0.28 to 0.89
Inappropriate abbreviation	1	0.22	0.06	0.003 to 0.25	0.04	0.003 to 0.19

*Rate calculations based on data from 1782 patients and 2259 prescriptions.

Table 4 Medications categories associated with errors

Medication category	Medication errors with minimal potential for harm			Near misses		
	n	Percentage of events*	Percentage of Rx†	n	Percentage of events*	Percentage of Rx†
Penicillin or derivative	501	42	72	91	20	13
Bronchodilators, inhaled	59	5	30	45	10	23
Macrolides	81	7	77	34	7	32
Steroids, topical	49	4	47	26	6	25
Ophthalmic preparations	87	7	79	42	9	38
Ibuprofen	38	3	46	24	5	29
Steroids, inhaled	29	2	36	25	5	31
Antifungal, topical	42	3	57	13	3	18
Antihistamine	36	3	42	16	3	19
Steroids, oral	35	3	64	22	5	40
Emollients	31	3	148	1	0.22	5
H2 blocker	—	—		1	0.55	6
Topical	24	2	43	8	2	14
Leucotriene receptors	23	2	88	3	0.65	12
Cephalosporins	13	1	21	7	5	12
Acetaminophen	15	1	38	18	4	45
Otit prep	13	1	43	7	5	23
Gi meds	12	1	300	—	—	—
Dermatologicals	12	1	32	8	2	21
Antifungal oral	10	1	24	13	3	31
Vitamins	10	1	40	7	2	28
Antimalarial	8	1	160			
Topical anaesthetic	7	1	2	2	0.43	7
Bronchodilator oral	1	0.08	8	5	1	42
Antituberculosis	5	0.41	71	4	0.86	67
Antitussive	—	—	—	4	0.86	15
Decongestant	5	0.41	71	4	0.86	57
Antiviral	—	—	—	1	0.22	25
Laxative	5	0.41	25	4	0.86	20
Analgesic	—	—		6	1	67
Other meds	24	2	126	5	1	26
Proton pump inhibitor	—	—	—	—	—	—
Stimulants	6	0.50	29	4	0.86	19
Sulfa	4	0.33	33	2	0.43	15
Scabicides	1	0.08	14	3	0.65	9
Antihelminitics	2	0.17	50	2	0.43	50
Epinehprine	5	0.41	38	2	0.43	15
β blocker	—	—	—	1	0.22	100
Cerumenolytic	—	—	—	1	0.22	33
Muscle relaxant	—	—	—	1	0.22	50
Normal saline	3	0.25	11			
Antitussive	2	0.17	7			
Thyroid agent	2	0.17	200			
Immunologicals, topical	2	0.07	67			
Nasal spray	1	0.08	7			
Iron	1	0.08	20			
Haemostatic	1	0.08	50			
Topical oestrogen cream				2	0.43	22

*Proportion of incidents attributable to a given drug category. For example, penicillin or derivative prescriptions caused 20% of near misses.
†Proportion of prescriptions for a given drug category that resulted in an incident. For example, 13% of penicillin or derivative prescriptions resulted in a near miss.

patients; 95% CI 10 to 13%). The methodology employed in this study has been used in multiple previous studies.[2 5 6 8–10] Throughout all of this work, inappropriate abbreviations were consistently defined as errors. We agree that many had minimal potential for harm but are deviations from practice, and therefore, we have categorised them as errors. The rate of dosing issues was similar for medication errors (rate: 6% of patients; 95% CI 5 to 7%) and near misses.

Medication errors by drug category

A notable portion of medication errors (42%) and near misses (20%) involved penicillin or its derivatives (table 4). Some groups

of medications, including emollients, gastrointestinal medications, antimalarial drugs and thyroid agents averaged more than one mistake per prescription.

Sources of errors

Illegibility and weight-related errors were prevalent sources of errors, and we report them separately from medication errors. We found 670 illegibility errors (table 5). Of the illegibility errors, 489 had illegible physician signatures. Errors in documentation of patients' weight were nearly as common (667 errors). The most frequent weight-related errors were omission of weight information (73%) and omission of weight units (27%).

Rule violations

Of the 212 detected rule violations, 'as needed' (PRN) without indication (48%) and unspecified length of treatment (with correct dispensing amount; 43%) were most frequent.

DISCUSSION

Medication errors were extremely frequent in this study: half of prescriptions had errors, and a fifth had errors with the potential for harm. This study employed the methodology used in several previous studies, suggesting that high rates of errors found in this study were not due to methodological differences.[2 5 6 8–10] Eighty-five per cent of all errors occurred in the ordering process. In addition, there were many administration errors among near misses.

It is still unclear if non-harmful errors are similar to or predictive of harmful errors. Therefore, we undertook this epidemiological study to understand the differences between non-harmful and potentially harmful medication errors and to target areas for improvement. The most frequent causes of errors with minimal potential for harm were inappropriate abbreviations, followed by route and amount issues. In contrast, the most frequent causes of near misses were errors in dosing, frequency and other issues such as drug–allergy and drug–drug interactions. Therefore, the results of this study appear to indicate a difference between harmful and potentially harmful medication errors, suggesting that different strategies may need to be employed for each type of error.

Table 5 Frequent causes of medication errors with minimal potential for harm

Category of error	Medication errors with minimal potential for harm (n (%))
Illegibility errors	670 (100)
MD signature illegible	489 (73)
Illegible strength or strength units	43 (6)
Illegible patient name	30 (5)
Illegible duration	20 (3)
Illegible dispense amount	21 (3)
Illegible weight	12 (2)
Other	11 (2)
Illegible date	10 (1)
Illegible frequency or frequency units	9 (1)
Illegible dose	8 (1)
Illegible directions for use	8 (1)
Patient name spelled wrong	7 (1)
Illegible script	1 (<1)
First name initial only	1 (<1)
Weight errors	667 (100)
Omitted	487 (73)
Units missing	178 (27)
Wrong	2 (<1)
Date errors	72 (100)
Missing	43 (60)
Wrong	23 (32)
Other	6 (8)

In the paediatric outpatient setting, the rates of near misses and errors with minimal potential for harm far exceeded the rates of comparable errors in the adult setting.[8] Near misses, if not addressed, can lead to significant patient harm, and the high rates seen in the paediatric outpatient setting are cause for concern. Compared with a similar adult study, the rate of ordering-related near misses was four times higher in children (12.3 vs 3.3%), and the rate of errors with minimal potential for harm was more than 12 times higher (50.2% vs 4.2%).[5] The many calculations required in paediatrics to do weight-based dosing may be an important factor contributing to the high rates of prescribing near misses. Of the near misses, 23% occurred at the administration stage, which is similar to paediatric ambulatory ADEs.[6] Targeted prevention strategies to decrease errors at this stage are particularly important in paediatrics, as there are few proven interventions to address administration errors.

Electronic prescribing (e-prescribing) with clinical decision support is a widely noted strategy for reducing medication errors.[10] E-prescribing systems ensure that prescriptions are legible, complete and in a standard format. Most e-prescribing systems provide decision support, such as default doses, which would further reduce errors.[11] Despite tremendous promise, e-prescribing is not a panacea for medication ordering errors. Important considerations include cost, physician resistance to changes in workflow, lack of technological support and difficulties in choosing among systems and integrating with other systems.[12 13]

This study found a high rate of illegibility errors which may be important because of potentially significant misinterpretation of prescriptions or delays in a patient obtaining the intended medication. For example, when there is a problem in a prescription with an illegible prescriber's signature, the pharmacist may need to contact the patient for their prescriber's name, which could result in delays in obtaining the medication.

Our study has several limitations. Over 50% of prescribers in the study were residents. It is unknown whether resident prescribing patterns are different from non-resident prescribers. It should also be noted that residents tend to see a higher Medicaid population, and it is unclear whether Medicaid insured children have higher rates of medication errors. We obtained data from six office practices in Massachusetts. Although the practices served diverse populations, the generalisability of the study may be limited by the number of practices. In addition, physicians were not blinded to the purpose of the study, and physician awareness could have affected the incidence and detection of errors. This study demonstrates that medication errors with minimal potential for harm and near misses were very common in the paediatric ambulatory setting. Most medication errors occurred during the ordering stage. The vast majority could have been intercepted by e-prescribing systems. Results of this study may inform national discussions regarding technologies that promote medication safety among children, though further studies are urgently needed.

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