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The pharmaco-epidemiology of medication errors for children treated in the emergency department

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1. Introduction

Emergency care for children is a high risk setting for medication errors.¹ Patients are generally unknown to emergency department (ED) staff, may have significant medical complexity, and are receiving care in a busy environment with frequent provider interruptions. In addition, most children receive care in a general ED, which sees patients of all ages and may have a low pediatric visit volume.¹ These barriers complicate the existing challenges around pediatric medication dosing, including difficulties accurately reporting weight and calculating a weight-based dose, and the lack of standard pediatric dosing and formulations.¹

In addition to medications administered in the ED setting, there is also an error risk for medications recommended for use after discharge from the ED. These include both over-the-counter (OTC) medications described in discharge instructions, and prescriptions to be filled at a pharmacy and dosed at home. Pediatric OTC medications can be particularly challenging to dose, with inconsistencies between package instructions and dosing device markings.² In addition, ED patients have high rates of limited health literacy,³ which has been associated with increased challenges with understanding and implementation of dosing instructions.⁴ Patients with limited health literacy and limited English proficiency are at particular risk of dosing error.⁵ The goal of this editorial is to provide a brief summary of the

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Declaration of Interest

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literature on medication errors for children treated in the emergency department, with a particular focus on errors of commission.

2. Medication errors in the ED

2.1 Epidemiology

Single-center studies in pediatric EDs report a rate of medication error ranging from 10% to 31%,¹ with errors most often related to inaccurate weight, duplicate doses and miscalculation.⁶ One study reported the following outcomes of errors: no deaths or permanent disability, 13% patient harm, 47% reached patient (no harm) and 30% near miss or unsafe conditions.⁶ Another study examining error rates among orders and prescriptions in a pediatric ED found a rate of 0.78 errors per medication order or prescription with 14% of the population exposed to a serious error (98% near misses, 2% preventable adverse drug events).⁷ The most commonly reported medication events in a study of incident reports in pediatric EDs were wrong dose, incorrect medication and delayed or missing dose. Wrong dose was most often related to incorrect weigh (20%) either due to unit errors (pounds v. kilograms) or another vital sign reported as the weight (e.g. temperature), duplicate doses (21%) or calculation errors (22%).⁶

However, many studies have relied on incident reports,⁶ or pharmacy call-backs to the ED,⁸ both of which may result in undercounting of events. In addition, a simulation study (2004) suggested that certain errors could be identified only by analyzing syringe concentrations, which would also suggest that incident reports undercount the true rate of error.⁹ In addition, pediatric EDs may have a lower rate of error due to greater experience with children, pediatric-specific EMR modifications, and protocolized systems of care for children. The reported error rates probably underestimate error rates in the ED.

2.2 Interventions

Potential interventions to reduce error include computerized order entry, standardized formulary, ED pharmacists, and increased training, {Benjamin, 2018 #1048; {Kaufmann, 2012 #1458} but there is limited data to evaluate the effectiveness of these interventions to identify the best combination of practices. Computerized order entry with an electronic medication alert system significantly reduced the rate of error from 10 to 7 per 100 prescriptions. However, the sensitivity and specificity of the alert system were low at 45% and 57% respectively, and 11% of true dosing alerts were overridden by providers.¹⁰ In another study, electronic tools to obtain a more accurate medical history and medication list from parents were not successful in reducing medication error.⁷

2.3 Future research directions

Despite a broad recognition of the importance of medication safety for children in the ED,¹ there is limited evidence regarding the best practices to reduce errors for medications dispensed in the ED. The electronic medical record could potentially be used to improve identification of errors. Accurate national data on the true rates of error, and the variation between centers, would be very helpful¹¹ to researchers and to policy makers. In particular, additional work is needed to assess pediatric medication errors in general EDs, rather than

pediatric-only centers. Human-factors design and engineering studies are needed to optimize computer order entry and systems of care to reduce the risk of error and improve patient safety.

3. Medication errors following ED care

3.1 Epidemiology

One study examined a random selection of electronic prescriptions written by residents in a pediatric ED, and found that 16% had at least one error. Of those, 17% were described as significant, such as incorrect dose or directions for the medication.¹² In this study, emergency medicine residents had a significantly higher rate of error than pediatric residents.¹² A study from a pediatric ED in Spain found a rate of 15% for prescription error, of which approximately half were inappropriate indication and half were inappropriate dose. In this study, 95% of errors were considered insignificant, 5% were moderate and none were severe.¹³ Discharge teaching in the ED only rarely includes clear dosing instructions. For example, in one study, 63% of parents were told to use acetaminophen, but only 37% were told the dose and only 4% had the measurement of the dose demonstrated.¹⁴ The result was that 32% of parents had an acetaminophen dosing error when assessed immediately after ED discharge, despite provision of a dosing instruction sheet.¹⁴ In this study, Spanish-speaking parents had a significantly increased risk of error, even after adjustment for language of discharge instructions, income and health literacy.¹⁴ Parents receiving care in the ED have also been found to have high rates of using non-recommended dosing devices (such as spoons) and lack of knowledge of weight-based dosing (68%),¹⁵ putting them at increased risk of dosing error after an ED visit.

3.2 Interventions

Several studies have demonstrated that improved discharge teaching strategies can reduce the risk of subsequent medication error after an ED visit. Both an intervention combining plain language instructions with pictograms¹⁶ and one combining advanced counseling strategies, such as teach-back, pictures, and demonstration, and provision of a dosing instrument, have been associated with decreased risk of error.¹⁷ Interestingly in the later study, neither the counseling nor the provision of the dosing instrument were successful alone.¹⁷ These data suggest that interventions including improved discharge teaching strategies and provision of a standardized dosing device may help reduce medication errors following ED discharge.¹

3.3 Future research directions

Electronic medical records and computer order entry have the potential to improve identification of prescription error and enable interventions to reduce prescribing errors, and more research is needed to identify best practices and strategies for design and implementation of those strategies. In addition, additional research is needed to identify the optimal strategy for discharge instructions and parental teaching to enable families to safely dose medications, particularly liquid medications, at home. In the same way as other complex ED processes of care (e.g. sepsis) are protocolized with existing order sets, checklists, and team training, medication teaching at discharge may benefit from a

standardized approach across providers. To develop such a system, additional work is needed to identify the best practices for efficiently communicating medication instructions for parents across a diverse spectrum of language and health literacy. Finally, once candidate best practices are identified, a significant implementation and dissemination study will be required to understand how to best expand the scope of these interventions to all EDs that care for children.

4. Conclusion

Overall, despite the wide consensus on the importance of addressing medication errors to improve the safety of emergency care for children, national data on the prevalence of type of error is limited, hindering quality improvement and benchmarking efforts. There is increasing evidence, and expert consensus, regarding strategies for reducing rates of medication error in the ED and at home following an ED visit (Table). More work is needed to rigorously test these strategies and develop the dissemination and implementation plan to encourage broad utilization of successful strategies.

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Table:

Error type, challenges, potential solutions and opportunities for future research

Error location	Error type ⁶	ED Challenges	Potential solutions	Research opportunities and next steps
<i>Within ED</i>	Allergy	Alert fatigue; incomplete information	Improved accuracy of allergy alerts; pharmacist review of medications	Data sharing between EMRs; ED pharmacy staffing models
	Delayed or missed dose	High ED volume/crowding	Improved EMR notifications	Alternate notification strategies for front-line-clinicians; ED pharmacy staffing models
	Wrong dose	Low volume of pediatric patients; provider knowledge	Provider education CPOE systems/electronic prescribing Pharmacy review	Optimal provider education strategies; improving CPOE systems
	Wrong medication	High ED volume/crowding; look-alike-sound-alike medications	Bar code scanning for medications	Improved CPOE defaults for pediatrics
	Wrong patient	High ED volume/crowding	Bar code scanning for medications	Novel safety strategies for high volume, high acuity settings
	Wrong route	Provider knowledge; communication challenges in a fast-paced environment	Computerized physician order entry systems/ electronic prescribing Pharmacy review	Improved CPOE defaults for pediatrics
<i>At home, following ED care</i>	Prescription error	Low volume of pediatric patients; provider knowledge; incorrect CPOE defaults	Improved pediatric defaults; pharmacy review	Improved CPOE defaults for pediatrics
	Discharge instruction error	Limited time for discharge instructions; poor quality of template instructions	Improved provider education; advanced teaching strategies; provision of dosing instrument	Rapid, efficient, teaching strategies for providers
	Parental medication error (dose or frequency)	Limited health literacy; OTC instructions confusing; liquid medications difficult to dose accurately	Dose demonstration, teach-back	Identification of optimal strategies for parental education

Abbreviations: ED, emergency department; EMR, electronic medical record; CPOE, computerized provider order entry; and OTC, over the counter.