HHS Public Access

Author manuscript

Pediatr Crit Care Med. Author manuscript; available in PMC 2018 April 01.

Published in final edited form as:

Pediatr Crit Care Med. 2017 April ; 18(4): 370–377. doi:10.1097/PCC.0000000000001090.

Medication Reconciliation Failures in Children and Young Adults with Chronic Disease During Intensive and Intermediate Care

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Abstract

Objectives—Although medication reconciliation has become standard during hospital admission, rates of unintentional medication discrepancies during intensive care of pediatric patients with chronic disease are unknown. Such discrepancies are an important cause of adverse drug events in adults with chronic illness and are associated with unintentional discontinuation of chronic medications. We sought to determine the rate, type, timing and predictors of potentially harmful unintentional medication discrepancies in children and young adults with chronic disease.

Design—Prospective observational cohort study.

Setting—Patients discharged from the Intensive and Intermediate Care Units at a tertiary care children's hospital from September 2013–May 2014.

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Conflict of Interest: The authors have indicated they have no potential conflicts of interest to disclose and no additional financial relationships relevant to this article to disclose.

Contributors' Statements

Danielle DeCourcey: Dr. DeCourcey conceptualized and designed the study, drafted the initial manuscript, approved the final manuscript as submitted. Dr. DeCourcey had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis

Melanie Silverman: Ms. Silverman supervised the data collection, carried out the initial analyses, wrote the methods section, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Esther Chang: Dr. Chang took the medication histories and completed all of the reconciliations and initial error evaluation, reviewed and revised the manuscript and approved the final manuscript as submitted.

Alexandra Oldershaw: Ms. Oldershaw designed the data collection instruments, coordinated and supervised data collection and approved the final manuscript as submitted.

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Al Ozonoff: Dr. Ozonoff carried out all of the secondary analyses and statistical modeling, wrote the statistical analysis section, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Jonathan Finkelstein: Dr. Finkelstein participated in study design, data analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Patients—Consecutive sample of 308 patients less than 25 years of age with chronic disease defined by prescription of at least one predetermined class of chronic medication prior to hospitalization.

Measurements and Main Results—The number of unintentional medication discrepancies with the potential for harm, as well as patient and medication-related factors predisposing patients to these errors were assessed. 2739 medication discrepancies were identified; 284 (10%) were unintentional and had the potential for harm (0.9 per patient). Of these, 128 (45%) were due to errors in taking the preadmission medication history, while 156 (55%) were due to errors reconciling the medication history with orders. Most events occurred on admission (66%) and were dosing errors (45%). In multivariable negative binomial regression analyses (adjusted rate ratios [95% CI]), each additional preadmission medication (1.07 [1.04–1.10]), chronic respiratory medications (1.51 [1.01–2.28]) and chronic non-invasive ventilation (1.53 [1.07–2.19]) were associated with increased risk of a discrepancy.

Conclusion—Unintentional medication discrepancies with the potential for harm are common among children and young adults with chronic disease during critical care admission due to both failure to obtain an accurate medication history and errors in reconciling the history with patient orders. The use of current medication reconciliation processes is insufficient to prevent errors in this high risk population.

Keywords

Medication errors; medication reconciliation; pediatric intensive care units; chronic disease; near miss; healthcare; health services research

INTRODUCTION

Several recent studies suggest that adults prescribed medications for chronic disease are at increased risk for unintentional discontinuation of these medications during hospitalization and after discharge (1–3). These risks are even higher for patients admitted to an ICU, with contributing factors including the practice of temporarily discontinuing chronic medications during critical illness as well as frequent transitions in care (1, 4).

Among hospitalized and recently discharged adults, unintentional medication discrepancies, defined as unexplained differences among documented regimens across different sites of care, are an important cause of adverse drug events (ADEs). Up to 66% of unintentional discrepancies at admission or discharge may cause direct patient harm, prolonged hospitalizations, emergency department visits and readmissions (5, 6). Among critically ill patients, the frequency of ADEs is up to three times higher in patients admitted to pediatric hospitals than in adults because of complexities associated with weight-based dosing, custom medication formulations and the inability of children to communicate adverse effects(7). Additionally, children with chronic illnesses as well as those with medical complexity may be at special risk for medication errors (8, 9,25, 26).

The Joint Commission designated inpatient medication reconciliation as a national patient safety goal in 2005 and since then has required organizations to "compare the medication information the patient brought to the hospital with the medications ordered for the patient

by the hospital in order to identify and resolve discrepancies"(10). As such, the process of medication reconciliation has become standard practice for all admissions and discharges at pediatric institutions across the United States. Medication reconciliation has been defined as the process of creating the most accurate list of preadmission medications and comparing this against the admission, transfer and discharge orders, with the aim of providing the right medications at all transition points within the hospital (11). Although some pediatric studies support medication reconciliation as a means to reduce ADEs (12, 13), primarily through the reduction of medication discrepancies, a recent review suggests continued uncertainty regarding the frequency and nature of these discrepancies in pediatrics (8).

Therefore, we sought to determine the number of unintentional medication discrepancies among those admitted to intensive care, as well as those discrepancies with the potential for harm (potential adverse drug events or PADEs). PADEs have been described as “incidents with the potential for injury related to a drug” (14). Because little is known about the circumstances or predictors of PADEs in pediatric and young adult patients with chronic disease, we then classified these discrepancies in terms of type, timing, and reason and identified patient and medication-related factors that predispose pediatric patients to these errors.

MATERIALS AND METHODS

Study Design, Setting and Participants

Patients <25 years of age with preexisting chronic disease were studied prospectively during admission to a 10-bed Intermediate Care Unit (InCU) and 12-bed Medical Intensive Care Unit (MICU) at Boston Children’s Hospital from September 2013–May 2014. These units cared for a wide variety of medical patients but generally excluded post-operative surgical patients. Patients with chronic disease were defined as those prescribed at least one major class of a pre-specified group of chronic medications [Supplemental Table 1] prior to hospitalization, and included a spectrum of children and young adults from those with single organ system disease (e.g. asthma) to those with multiple complex chronic conditions and technology dependence. The hospital’s electronic medical record utilizes a medication reconciliation module in which the medical team takes a medication history, enters a preadmission medication list within 24 hours of admission, and reconciles medication orders at admission and discharge with this medication list. The Institutional Review Board approved this study; the requirement for patient consent was waived.

The primary outcome was the number of PADEs per patient. PADEs were identified using a previously published 2-step process (15). First, one of two experienced ICU hospital pharmacists obtained a “gold standard” preadmission medication history within 24 hours of admission to the MICU or InCU. This was performed utilizing a previously published, strict protocol (15) and using all available sources of information including the caregiver, prescription bottles, electronic medical record, and outpatient pharmacies if necessary. After the discharge orders were written, the resulting “gold standard” preadmission medication list was then compared with the medical team’s preadmission medication list to identify history errors and with all admission and discharge medication orders to identify reconciliation errors. Discrepancies between the “gold standard” preadmission medication list and

medication orders were identified. Medication discrepancies were identified as "unintentional" by the study pharmacist after review of the patient's medical records and, if necessary, discussion with the medical team to clarify reasons for the discrepancy. Any errors discovered by the study pharmacist that were not detected during the natural process of care were brought to the attention of the primary team that had cared for the patient. The clinical status of all study patients, as well as the hospital's safety event reporting service, was monitored during the study period to evaluate actual harm to patients.

Second, unintentional discrepancies were reviewed by an adjudication team comprised of two critical care attending physicians and a critical care nurse practitioner, all with at least 5 years of pediatric critical care experience. Using a published expert-derived classification scheme (15), the adjudicators and the study pharmacists recorded details of the unintentional medication discrepancy, including the timing of the discrepancy (e.g. admission vs. discharge), the type (e.g. omission, dose change, etc.), and the reason (history vs. reconciliation error). PADEs were counted once per medication per discrepancy time point, even if the medication had more than one type of discrepancy. History errors were defined as errors in taking or documenting the patient's preadmission medication history (e.g. not including fluticasone on the preadmission medication list resulting it not being ordered at discharge). Reconciliation errors were defined as errors reconciling the medication history with medication orders at admission and discharge (e.g. fluticasone is on the preadmission medication list, intentionally held at admission, but not restarted at discharge despite being clinically indicated). Independently, two reviewers judged the potential for harm and potential severity (significant, serious, or life threatening) of each unintentional discrepancy as previously described (15). The inter-rater reliability for physician adjudicator evaluation was also calculated, with a kappa of 0.87 for potential for harm and 0.80 for potential severity. All disagreements were resolved by discussion and by a third adjudicator, if necessary.

Predictors of PADEs

We explored the relationship between PADEs and potential contributory patient, system, and medication-level factors, which were chosen a priori and collected through chart review. These risk factors included gender, age, race, number of preadmission medications (excluding "as needed" medications and topical agents), preadmission medication class, admission source, reason for admission, need for more than one critical care transfer, hospital length of stay, admitting clinician's level of training (resident, intern, nurse practitioner/hospitalist), need for non-invasive ventilation or tracheal intubation during hospitalization, and markers of medical complexity and chronic technology dependence including presence of an enteral feeding tube (gastrostomy only vs jejunostomy or gastrojejunostomy), tracheostomy, baseline non-invasive ventilation or baseline ventilator dependence at the time of admission and number of co-existing chronic conditions.

Statistical Analysis

Patient characteristics were described using frequencies, means with standard deviations and medians with interquartile ranges. Bivariate and multivariable analyses were conducted using negative binomial regression to determine associations between patient-level

characteristics and the number of PADEs per patient, as well as number of history and reconciliation PADEs per patient, with results reported as adjusted rate ratios (ARR [95% CIs]). Predictors were evaluated for colinearity and no adjustments were made for multiple comparisons (16). We fit all models using the R statistical package (R Foundation 2014, v3.1.0). For model selection, we began with a list of candidate predictors and used a backwards stepwise selection procedure with retention threshold and a two-sided significance level of p=0.05 for all hypothesis tests unless otherwise noted.

RESULTS

Description of Study Sample

We enrolled 308 patients including 125 patients in the MICU and 183 in the InCU [Table 1]. Patients were primarily White (59%), admitted from the ED (48%), and had respiratory complaints (74%). 62% of patients had chronic technology dependence and 28% had greater than 3 chronic conditions. The median number of preadmission medications was 9.

Frequency of Discrepancies and PADEs—Among these 308 patients, 2,739 medication discrepancies were identified, of which 413 (15%) were unintentional. Of these 413 unintentional errors, 284 (69%) had potential for harm, yielding an average of 0.9 PADEs per patient [Figure 1]. 134 (44%) patients experienced at least one PADE, 73 (24%) had two or more PADEs and 14 (5%) had five or more PADEs during hospitalization. Of all PADEs, 232 (82%) had the potential to cause significant harm. Examples of significant harm include errors with the potential for re-hospitalization or temporary alteration in organ function. The remaining errors had the potential for serious harm resulting in permanent alteration in health, 47 (16%), or were considered life threatening, 5 (2%), if not corrected.

Classifying PADEs

Figure 1 shows the classification of PADEs. 128 (45%) were due to errors taking the preadmission medication history, while 156 (55%) were due to errors reconciling the preadmission medication history with admission or discharge orders. Among both history and reconciliation PADEs, most occurred on admission (61 and 71%, respectively). Although some errors were caught during the hospitalization, approximately one in three patients had a PADE in their discharge orders. 168 patients were discharged directly home from the ICUs and 43% of those patients had at least one PADE in their discharge medication orders. Changes in dose (45%), frequency (40%) and drug omissions (26%) were the most common error types encountered.

The most common medication classes involved in PADEs were respiratory (39%), gastrointestinal (24%) and neurologic (20%). Because certain medication classes are prescribed more frequently, we also calculated event rates adjusted for prevalence of use. The three medication classes at highest risk for PADEs were respiratory (117/733 prescriptions) with errors in asthma medication prescribing most common, metabolic (6/56 prescriptions) with errors in levocarnitine most common, and endocrine (12/111 prescriptions) with errors in hydrocortisone and levothyroxine occurring most frequently.

Characteristics of Patients with PADEs

In bivariate analysis, several patient-level risk factors were associated with a higher number of PADEs [Table 2]: age, number of preadmission medications, direct admission to ICUs from an outside facility, ≥3 coexisting conditions, admission for cardiovascular reasons, and chronic technology dependence including presence of a gastrostomy tube (G-tube) or need for non-invasive ventilation. Black and other race patients had a lower incidence of PADEs compared to Non-Hispanic Whites, as did inpatients that were transferred to the ICUs from the pediatric wards compared to those admitted from the ED. Similar patient-level factors were associated with a higher incidence of PADEs [Table 2] attributable to errors in taking an accurate medication history [History PADEs] and errors reconciling the patient history with their medication orders [Reconciliation PADEs]. We did not find any significant differences in the frequency of PADEs based on the experience level of the admitting clinicians.

Predicting PADEs

In the multivariable model, each additional preadmission medication was associated with increased risk of PADEs (1.07 [1.04–1.10]) [Table 3], as was use of chronic respiratory medications (1.51 [1.01–2.28]) and chronic non-invasive ventilation (1.53 [1.07–2.19]. When compared to Non-Hispanic Whites, Black (0.48 [0.25–0.91]) and other race (0.62 [0.42–0.93]) was associated with a lower incidence of PADEs. Presence of a J-tube (0.58 [0.38–0.89]) and transfer to the ICUs from the pediatric wards (0.54 [0.36–0.80]) were associated with a lower incidence of PADEs. For History PADEs, each additional medication was again associated with a higher incidence of error (1.10 [1.06–1.15]), while more than critical care transfer conferred a lower risk of History PADEs (0.35 [0.15–0.81]). Each additional medication was also associated with a higher incidence of Reconciliation PADEs (1.08 [1.05–1.11]), as were the need for chronic non-invasive ventilation (1.71 [1.15–2.53]), and more than one critical care transfer (1.88 [1.07–3.30]). When compared to Non-Hispanic White race, Black race (0.31 [0.12–0.79]) was associated with a lower incidence of Reconciliation PADEs. Presence of a J-tube (0.42 [0.26–0.70]) and transfer to the ICUs from the pediatric wards (0.44 [0.25–0.78]) were also associated with a lower incidence of Reconciliation PADEs. All remaining predictors fell out of the multivariable models during stepwise regression, and were thus excluded.

DISCUSSION

Patients with chronic disease may have important medications intentionally or unintentionally withheld during ICU admission and are at increased risk for unintentional medication discontinuation following hospital discharge (1, 2, 17). Efforts to improve the quality and safety of health care for patients with chronic illness includes attention to unintentional medication discrepancies (18). This study provides a comprehensive evaluation of the extent, causes, and clinical significance of medication discrepancies at transitions of care in pediatric patients with chronic disease during intensive and intermediate care. We found a high prevalence of PADEs, with 44% of patient's experiencing at least one PADE in admission or discharge orders and 24% having two or more errors. Despite differing techniques and settings, these error rates are comparable to

those observed in both adult and other pediatric studies (15, 18–22). Many of these studies, however, were performed prior to the widespread adoption of medication reconciliation. Our findings suggest that current medication reconciliation practices do not appear to have resulted in significant improvement in the errors they were intended to prevent.

In our study, PADEs most commonly occurred at admission and involved dosing errors. This differs from PADEs in adult patients, which most commonly occur at discharge and involve medication omissions (1, 2, 15). The increased frequency of dosing errors in pediatrics is not surprising given the complexities of weight-based dosing and prevalence of custom medication formulations; others have reported similar findings in a general pediatric ward and pediatric ICU (23). Our finding that 43% of patients discharged directly to home had an error in their discharge medication orders is also consistent with studies of adults which found one third of patients had at least one chronic medication omitted at hospital discharge (2) and in pediatrics where 43% of patients had an error in their discharge medications(24). This is particularly significant for children with chronic illness, as unintentional errors may place high-risk patients at further risk for avoidable morbidity. Our finding that PADEs are more often caused by errors in reconciliation (55%) rather than history errors may suggest that computerized physician order entry medication reconciliation has introduced new challenges to the reconciliation process (13, 19).

We found the vast majority of unintentional discrepancies had the potential to cause at least significant harm. Our findings are similar to those of a study evaluating admission medication reconciliation in children with medical complexity which found that 76% of PADEs had the potential to cause significant or serious harm and 19% of PADEs were potentially life-threatening (25). As our study evaluated PADEs after patient discharge, the clinical status of all study patients, as well as the hospital's safety event reporting service, were monitored to evaluate actual harm to patients. To our knowledge, none of the errors identified in this study resulted in patient resuscitation or permanent harm.

Although care transitions are widely believed to represent a time of heightened vulnerability to error, there are limited pediatric data regarding associated risk factors in the era of current medication reconciliation practices. In this study, we identified that the number of preadmission medications, the need for chronic respiratory medications and chronic non-invasive ventilation dependence were all significant predictors of the number of PADEs in multivariable analysis. These risk factors, present in more than 60% of our cohort, are a proxy for medical complexity. Children with special medical needs or dependence on medical technologies have significantly higher rates of hospital-reported medical errors(26) and as was also noted in our study, an increased number of chronic conditions is associated with medical errors in pediatric inpatients (27).

This study was conducted in the intensive and intermediate care units of a freestanding children's hospital and may not reflect care in community hospitals or other settings. In order capture patients with a wide spectrum of chronic disease complexity, we defined children with chronic disease as those prescribed at least one major class of a pre-specified group of chronic medications prior to hospitalization. It is possible that this approach, while likely specific for children with chronic disease, may not have captured those with rare

chronic diseases or those receiving atypical therapies. Additionally, patients with short stays may have been disproportionately discharged prior to enrollment, thus leading to selection of patients on more medications. Although, we utilized a previously published expert derived classification scheme to ensure objectivity and insured at least two independent reviews for each discrepancy, we cannot exclude the possibility that the physician and NP adjudicators may have introduced anchoring bias into the designation of PADEs. We also did not find the experience level of the admitting provider to be associated with PADEs, but note that attending physicians did not enter orders. While studies indicate that pharmacists are more reliable than other medical personnel in obtaining an accurate medication history (28), their "gold standard" preadmission history may also have contained errors. Also, it should be noted that gold standard medication histories took on average 45 minutes to complete and the feasibility of performing this rigorous type of medication history by providers is unknown. Lastly, while this study measured potential and not actual ADEs, other work has demonstrated that these unintentional discrepancies are closely associated with ADEs and can lead to suboptimal management of acute and chronic conditions, readmissions and death (17, 20,28–30).

To our knowledge, this is the first study to identify risk factors for unintentional medication discrepancies in children and young adults with chronic disease admitted to US intensive and intermediate care settings and highlights the scope of the problem and those at highest risk. Given the unacceptable frequency of medication errors affecting children and young adults with chronic illness, we believe that interventions to reduce patient harm must be directed at all stages of the process including history taking, reconciliation, dispensing and administration. The medication reconciliation literature is most robust for pharmacist–run interventions, which highlight the importance of obtaining an accurate preadmission medication history. Because history errors have great potential for harm even after discharge, interventions should be predicated on obtaining an accurate medication history from which to begin the medication reconciliation process (29). Furthermore, while there is evidence that medication reconciliation can reduce the number of unintended medication discrepancies at transfers of care, current medication reconciliation interventions adopted from adults may not be sufficient for application in children (31).

CONCLUSIONS

Unintentional medication discrepancies with the potential for harm are common among children and young adults with chronic disease during intensive and intermediate care, and those with medical complexity appear to be at particular risk. Errors occurred both from failure to take an accurate medication history and in reconciling that history with patient orders, indicating that use of current medication reconciliation practices on admission and discharge alone are insufficient to prevent ADEs in this high-risk population. Given the unacceptable frequency of errors noted in this study, interventions to improve medication safety must include the design and testing of new, multifaceted approaches that go beyond medication reconciliation. Areas of focus should include determining the value of increased pharmacist presence during hospital admission to improve the accuracy of history taking and improvements in computerized physician order entry specifically designed to reduce the number of mediation discrepancies throughout hospitalization.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding Source: All phases of this study were supported by The Program for Patient Safety and Quality at Boston Children's Hospital and by the National Institutes of Health (NIH) T32 HD 75727: Research Training in Prevention and Care of Chronic Illness in Childhood.

We would like to thank The Harvard Wide Pediatric Health Services Research Fellowship for their guidance.

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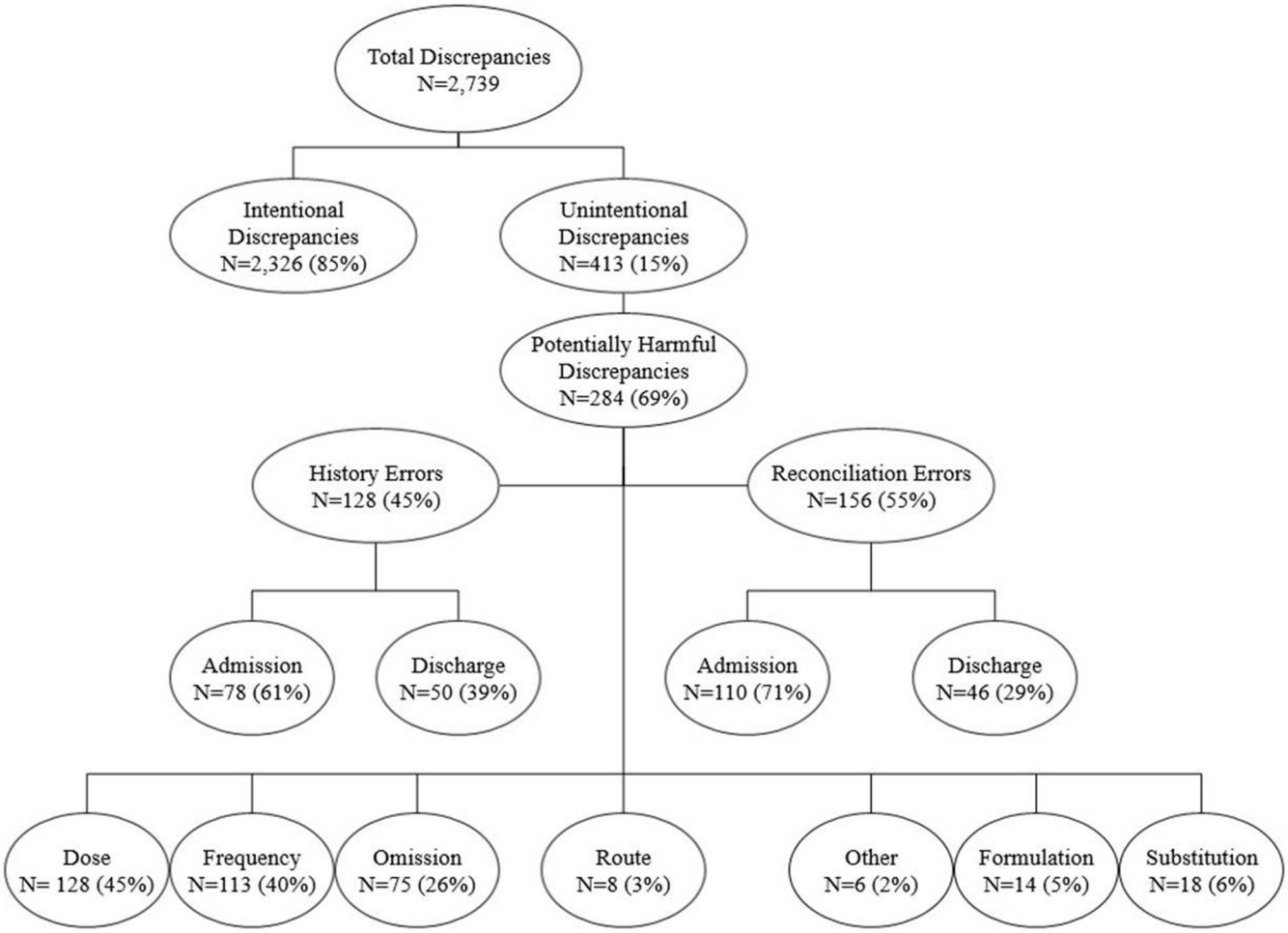

Figure 1. Classification of Medication Discrepancies

2,739 medication discrepancies were identified, of which 15% were determined to be unintentional. Of these unintentional errors, 69% had potential for harm, yielding an average of 0.9 PADEs per patient. The majority of PADEs were reconciliation errors (55%), occurred at admission (61%) and were errors in dose (45%) or frequency (40%).

Table 1

Patient Characteristics

Characteristics	Study Sample (n=308)
Age at admission, years (n [%])	
0–2	82 (27)
3–6	58 (19)
7–11	48 (16)
12–17	59 (19)
18–24	61 (20)
Gender	
Male (n[%])	157 (51)
Race (n[%])	
Non-Hispanic White	182 (59)
Black	36 (12)
Other	90 (29)
Number of preadmission medications (median [IQR])	9 (4–13)
Hospital LOS, days (median [IQR])	7 (3–18)
Admission location	
Intermediate Care Unit (InCU)	183 (59)
Medical Intensive Care Unit (MICU)	125 (41)
>1 Critical care transfer (n [%])	60 (19)
Reason for admit (n [%])	
Respiratory	227 (74)
Cardiovascular	29 (9)
Metabolic	18 (6)
Other	34 (11)
Admitting clinician	
Resident	124 (40.26)
Nurse Practitioner (NP) / Hospitalist	36 (11.69)
Intern	148 (48.05)
Admission source (n [%])	
Emergency department (ED)	148 (48)
Direct	61 (20)
In hospital Transfer	95 (31)
Operating room	4 (1)
Chronic technology dependence (n [%])	
Any	192 (62)
Gastrostomy tube	117 (38)
Jejunostomy tube	58 (19)
Non-invasive ventilation	68 (22)
Tracheostomy and ventilator dependence	20 (7)
Non-invasive ventilation during admission (n [%])	125 (41)

Characteristics	Study Sample (n=308)
Intubation during admission (n [%])	63 (20)
≥3 Coexisting chronic conditions (n [%])	86 (28)

Table 2

Bivariate Analyses of Risk Factors for Unintentional Medication Discrepancies with the Potential for Harm (PADEs)

Characteristics	PADE Rate Ratio [95% CI]	History PADE Rate Ratio [95% CI]	Reconciliation PADE Rate Ratio [95% CI]
Gender			
Male	0.95 [0.66–1.37]	1.20 [0.65–2.21]	0.78 [0.52–1.18]
Age, years			
0–2	Ref	Ref	Ref
3–6	2.27 [1.31–3.92] *	3.26 [1.27–8.35] *	1.77 [0.95–3.31]
7–11	1.59 [0.90–2.83]	2.14 [0.80–5.71]	1.32 [0.68–2.55]
12–17	2.59 [1.44–4.64] *	3.88 [1.43–10.52] *	1.94 [0.99–3.79]
18–24	2.75 [1.53–4.97] *	3.72 [1.35–10.27] *	2.27 [1.17–4.42] *
Race			
Non-Hispanic White	Ref	Ref	Ref
Black	0.33 [0.17–0.64] *	0.46 [0.17–1.27]	0.21 [0.08–0.56] *
Other	0.47 [0.31–0.72] *	0.41 [0.20–0.84] *	0.53 [0.33–0.85] *
Number of preadmission medications	1.09 [1.06–1.11] *	1.09 [1.05–1.13] *	1.09 [1.06–1.11] *
Hospital LOS, days			
<2	Ref	Ref	Ref
>2 and <5	1.08 [0.62–1.89]	0.62 [0.25–1.55]	1.92 [0.99–3.67]
>5 and <12	0.78 [0.46–1.37]	0.60 [0.26–1.43]	1.15 [0.60–2.23]
>12 and <26	0.63 [0.34–1.16]	0.50 [0.19–1.31]	0.87 [0.41–1.85]
>26	0.93 [0.51–1.68]	0.32 [0.11–0.91] *	2.06 [1.05–4.03] *
>1 Critical care transfer	0.89 [0.56–1.42]	0.51 [0.22–1.17]	1.26 [0.77–2.08]
Reason for admission			
Respiratory	Ref	Ref	Ref
Cardiovascular	1.80 [1.02–3.18] *	2.45 [0.95–6.31]	1.35 [0.70–2.60]
Metabolic	0.61 [0.25–1.47]	1.15 [0.32–4.16]	0.23 [0.05–1.03]
Other	1.56 [0.89–2.72]	1.76 [0.69–4.49]	1.42 [0.76–2.64]
Admitting clinician			
Resident	Ref	Ref	Ref
NP/Hospitalist	1.33 [0.73–2.44]	1.10 [0.39–3.10]	1.53 [0.80–2.93]
Intern	1.05 [0.71–1.55]	1.13 [0.59–2.15]	0.99 [0.63–1.54]
Admission source			
ED	Ref	Ref	Ref
Direct	1.56 [1.01–2.41] *	1.47 [0.70–3.08]	1.64 [1.00–2.68]
In-hospital transfer	0.60 [0.39–0.93] *	0.47 [0.23–0.99] *	0.72 [0.44–1.20]
Chronic technology dependence			
Gastrostomy tube	1.49 [1.03–2.14] *	1.43 [0.77–2.65]	1.54 [1.02–2.33] *

Characteristics	PADE Rate Ratio [95% CI]	History PADE Rate Ratio [95% CI]	Reconciliation PADE Rate Ratio [95% CI]
Jejunostomy tube	1.14 [0.72–1.81]	1.45 [0.68–3.08]	0.91 [0.53–1.57]
Chronic non-invasive ventilation	1.76 [1.16–2.65] *	1.62 [0.80–3.28]	1.88 [1.19–2.95] *
Tracheostomy and ventilator dependence	0.95 [0.52–1.73]	1.33 [0.51–3.46]	0.66 [0.31–1.40]
Non-invasive ventilation during hospitalization	1.12 [0.77–1.62]	0.78 [0.42–1.46]	1.49 [0.99–2.25]
Intubation	0.86 [0.54–1.36]	0.64 [0.29–1.40]	1.06 [0.64–1.76]
>3 Coexisting chronic conditions	1.54 [1.04–2.27] *	1.59 [0.82–3.05]	1.50 [0.97–2.33]
Medication Class			
Respiratory medication	2.38 [1.58–3.61] *	3.42 [1.67–7.00] *	1.87 [1.16–2.99] *
Gastrointestinal medication	2.11 [1.30–3.41] *	2.02 [0.92–4.42]	2.19 [1.23–3.89] *
Neurologic medication	2.09 [1.40–3.11] *	2.12 [1.09–4.11] *	2.07 [1.29–3.30] *
Metabolic medication	1.34 [0.90–1.98]	1.27 [0.65–2.47]	1.40 [0.90–2.17]

* Indicates $p<0.05$

Table 3

Multivariable Analyses of Risk Factors for Unintentional Medication Discrepancies with the Potential for Harm (PADEs)

Adjusted Risk Factors for All PADEs	Adjusted Rate Ratio (ARR)	95% CI
Race		
Non-Hispanic White	Ref	
Black	0.48	0.25–0.91
Other	0.62	0.42–0.93
Admission source		
Emergency department	Ref	
In-hospital transfer	0.54	0.36–0.80
Chronic respiratory medication	1.51	1.00–2.28
Number preadmission medications	1.07	1.04–1.10
Jejunostomy tube	0.58	0.38–0.89
Chronic non-invasive ventilation	1.53	1.07–2.19
Respiratory medication	1.51	1.00–2.28
Adjusted Risk Factors for History PADEs		
Number preadmission medications	1.10	1.06–1.15
>1 Critical care transfer	0.35	0.15–0.81
Adjusted Risk Factors for Reconciliation PADEs		
Race		
Non-Hispanic White	Ref	
Black	0.31	0.12–0.79
Other	0.67	0.42–1.07
Number preadmission medications	1.08	1.05–1.11
Admission source		
Emergency department	Ref	
In-hospital transfer	0.44	0.25–0.78
>1 Critical care transfer	1.88	1.07–3.30
Jejunostomy tube	0.42	0.26–0.70
Chronic non-invasive ventilation	1.71	1.15–2.53