BMC Pediatrics

RESEARCH Open Access

Assessing medication discrepancies in pediatric patients: a cross-sectional feasibility study using the Medication Discrepancy Taxonomy (MedTax) in a pediatric ward

Berre Mercümek[1,2*], Muhammed Yunus Bektay[2,3*], Selcuk Uzuner[4] and Fikret Vehbi Izzettin[2]

Abstract

Background Medication reconciliation (MedRec) is essential during transitions of care (ToC) to prevent errors, yet standardized tools to classify medication discrepancies are inconsistently applied in pediatrics. To address this gap, our study aims to assess the feasibility of the Medication Discrepancy Taxonomy (MedTax) in identifying and classifying medication discrepancies in pediatric patients during ToC.

Methods A prospective cross-sectional study was conducted on pediatric patients hospitalized between August 2022 and February 2023. Patients < 18 years, hospitalized for ≥ 24 h, and prescribed ≥ 1 medication were included. Pharmacist conducted MedRec during admissions and transfers, classifying discrepancies as intentional or unintentional; only unintentional discrepancies were further categorised using MedTax. Statistical analyses were performed using Jamovi version 1.6.

Results Among 105 patients (47.6% female; mean age 62.3 ± 61.3 months), the mean numbers of comorbidities and medications per patient were 0.75 ± 0.98 and 8.35 ± 5.56, respectively. In total, 518 medication discrepancies were identified, of which 47 (9.1%) were unintentional and 471 (90.9%) intentional. Among the unintentional discrepancies, 9 (19.2%) were partial and 38 (80.9%) were complete. All discrepancies were classified using MedTax, though 6.38% were difficult to categorize using the existing MedTax structure.

Conclusion This study shows the feasibility of using the MedTax taxonomy to identify and classify medication discrepancies in pediatric patients during ToC. While MedTax effectively categorized most discrepancies, challenges in classifying some highlight the need for refinement to address pediatric medication complexities. These findings emphasize the importance of developing tailored tools to improve medication reconciliation in pediatrics.

Keywords Patient safety, Pediatric, Medication reconciliation, MedTax, Medication discrepancies, Transitions of care

*Correspondence:
Berre Mercümek
berre.mercumek@hotmail.com; bmercumek@bezmialem.edu.tr
Muhammed Yunus Bektay
yunusbektay@gmail.com; muhammed.bektay@iuc.edu.tr

Full list of author information is available at the end of the article

Introduction

Ensuring patient safety is a fundamental goal of healthcare delivery, as it is crucial for the health of patients [1]. While healthcare interventions are designed to benefit patients, they inherently carry risks, including the potential for causing harm. A significant challenge within patient safety is to prevent avoidable harm throughout the course of therapy [2]. The pediatric population is particularly vulnerable to medication errors due to several unique factors. Medications for children often require adjustments that are not necessary for adults, such as precise dosing calculations and adaptations for size and weight [3–5]. Additionally, communication with families and caregivers regarding home medication therapy can be inadequate, further increasing the risk of errors [6–9]. As a result, ensuring the safe use of medications in pediatric care is crucial and demands effective strategies to enhance medication safety.

The World Health Organization's (WHO) *Global Patient Safety Challenge: Medication Without Harm* initiative places particular emphasis on improving medication safety in high-risk situations, polypharmacy, and transitions of care (ToC) [10]. ToC represents a crucial period for medication errors, occurring when patients move between different healthcare providers and care settings, as their needs and conditions change due to acute or chronic diseases. These transitions are recognized as high-risk scenarios because new medications are introduced, or existing ones are adjusted. Ensuring coordination and continuity of care during these transitions is crucial to maintaining safety as patients shift between various locations and levels of care.

ToC, especially hospital admissions and discharges, are critically important because studies show 6.1% to 63% of pediatric patients have a medication discrepancy, and many of these were considered clinically significant [11–15]. Approximately half of medication discrepancies arise from errors in obtaining the history of medications used prior to admission (45%) [5]. WHO emphasizes the importance of medication reconciliation (MedRec) for patient safety and continuity of care during transitions urging countries to prioritize actions in this regard [10].

MedRec involves systematically assessing a patient's current medications and resolving discrepancies by creating a complete and accurate list of all the medications the patient is taking. This list is compared with newly prescribed medications to identify changes in dose, frequency, administration mode, additions, or discontinuation. Unintentional changes can lead to medication errors due to incomplete histories, communication errors, misinterpretations, and regimen changes, resulting in adverse drug events, prolonged hospital stays, readmissions, worsening health conditions, and increased costs [16]. Approximately 66% of patients have at least one discrepancy during hospital admission, and about 34% have discrepancies at discharge, leading to adverse outcomes in pediatrics [17].

Implementing MedRec is a complex process that demands significant resource utilization, extensive organizational change, multidisciplinary collaboration, and workflow redesign [18]. Despite the WHO's Action on Patient Safety ("High5s") initiative aiming to standardize the MedRec process, various gaps and barriers persist [19]. These include a lack of role clarity, insufficient interprofessional collaboration, and limited organizational capacity, including personnel resources and time commitments [18]. For instance, many studies fail to use standardized tools for classifying medication discrepancies, resulting in inconsistencies [12, 15, 20, 21].

To address this issue, several tools have been developed to identify and categorize medication discrepancies, with some focused specifically on MedRec, while others address broader aspects of medication safety [22]. While some tools, are helpful in understanding the sources and contributory factors of medication discrepancies, their limited number of categories can make them less effective for comprehensive classification of discrepancy types [23–25]. To improve this, Almanasreh et al. introduced the Medication Discrepancy Taxonomy (MedTax) in 2020, a comprehensive taxonomy specifically designed to improve the identification, classification, and reporting of medication discrepancies during the MedRec process [26]. MedTax is particularly noteworthy because it is specifically designed for MedRec during ToC, making it highly relevant for this context [26].

However, while MedTax provides a more detailed framework for accurately classifying various types of medication discrepancies, its reliability and validity have not been thoroughly evaluated, particularly in comparison with other existing taxonomies [26]. The minimal pilot testing and lack of detailed application reporting raise concerns about its practical utility. Further real-world testing is required to assess its effectiveness. Existing studies on MedRec predominantly emphasize clinical outcomes while providing limited insight into the implementation of standardized tools, particularly for pediatric patients [18].

To address this gap, our study aims to assess the feasibility of the MedTax taxonomy in identifying and classifying medication discrepancies in pediatric patients during ToC. Addressing these challenges is essential for enhancing the effectiveness and standardization of MedRec during transitions of care for hospitalized children.

Ethical approval

This study was approved by the Local Ethics Committee of Clinical Research with decision number 11/5.

Methods

Study design and setting

A prospective cross-sectional study was conducted at the university hospital in Istanbul, Turkey, in the Child Health and Diseases ward, which includes a 30-bed pediatric inpatient unit where there are no in-ward pharmacists. Medication histories are routinely obtained by nurses and physicians, and medication reconciliation (MedRec) is not a standardized practice.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Clinical Research of Bezmialem Vakif University with the decision number of 11/5. This study has been reported according to recommendation of the (STROBE) criteria (See Supplementary 1) and study flow chart given in Fig. 1 [27].

Eligibility criteria

Patients aged < 18 years who were hospitalized for at least 24 h and received at least one medication, were eligible for inclusion. Exclusion criteria were admission for diagnostic purposes only, inability to be assessed by the pharmacist, or transfer to an external facility during hospitalization.

Sample size

Based on published literature, the required minimum sample size was calculated as 86 participants, assuming a 5% margin of error and 95% confidence interval [28]. Using these parameters, the effect size (w) was estimated at 0.48, with $\alpha = 0.05$ and $\beta = 0.05$, resulting in a study power of 0.95.

Data collection

Patients were evaluated according to inclusion criteria to identify medication discrepancies during hospital admissions and internal transfers. Data collection was conducted between August 2022 and February 2023, using a structured form developed by the researchers and adapted from existing literature (See Supplementary 2) [29–31]. The form included three main sections: demographic information (age, gender, weight, height),

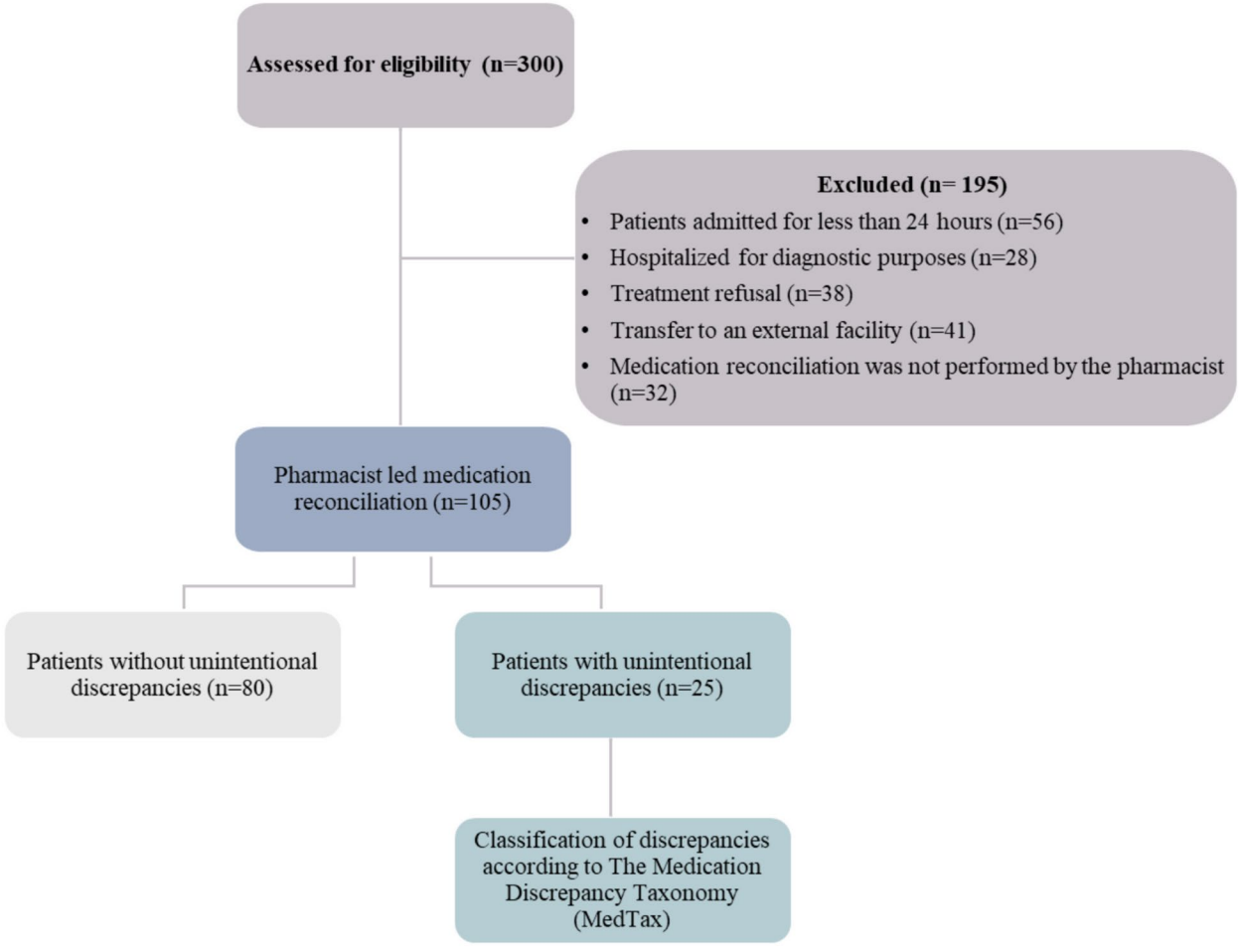

Fig. 1 Study flow chart

medical information (diagnosis, comorbidities, and laboratory findings such as biochemistry, hemogram, culture, and serological tests), and medication information. A comprehensive list of both prescription and non-prescription medications was created to establish the Best Possible Medication History (BPMH) list, encompassing details such as dose, dosage form, strength, frequency, and route of administration. For patients admitted directly to the ward, pre-admission medications were examined. For those transferred between wards, such as from intensive care or emergency to the ward, the most up-to-date medications used on the last day of their stay were reviewed to create the BPMH list. Information was collected through reviewing patients' medical records from the hospital's electronic records. Including medication orders, anamnesis, discharge summaries, patient files, medications they brought with them, and drug reports, as well as through interviews with the patient or their relatives, ensuring that at least two reliable sources were used. While the use of two reliable sources to compile the BPMH was implemented specifically for this study, it is not a routine practice at the study site. Data was collected by a clinical pharmacist master student within 48 h of patients' admission to the ward.

Assessment of medication discrepancies

This BPMH list was compared with the initial drug order made by the physician after admission to the ward, and any discrepancies determined. The differences between these two lists (drug additions, omission, dose changes, etc.) were determined and classified as 'intentional' and 'unintentional'. Intentional discrepancies were defined as purposeful changes made knowingly by the healthcare team, consistent with the patient's clinical condition, diagnosis, and laboratory data, as confirmed through consultation with the physician. In contrast, "unintentional" discrepancies, were defined as changes made unknowingly, such as omissions or incorrect dosages that were inconsistent with the intended treatment plan. This classification process did not rely on a specific published reference but was guided by clinical judgment and multidisciplinary discussions.

Only unintentional discrepancies, considered medication errors, were further categorized using the validated and reliable Medication Discrepancy Taxonomy (MedTax). MedTax is a systematic and hierarchical classification system that organizes medication discrepancies into two main categories: complete and partial discrepancies. Partial discrepancies are further divided into 6 primary categories, which are further subdivided into a total of 28 subcategories. For "partially" matched drugs, classification starts with the drug name and extends to factors such as the time of administration or duration of therapy. To ensure accuracy and avoid over-reporting, each discrepancy was categorized only once in accordance with the MedTax structure. In cases where any difficulties were encountered in the categorization, another researcher was consulted (MYB), and the final classification was decided by a consensus from two researchers.

Main outcome measures

The primary outcome is to assess the incidence of medication discrepancies in the sample group by determining their number and types using the MedTax classification.

Statistical analysis

Demographic data are expressed as percentage values; continuous and discrete variables are expressed with mean, standard deviation, median, interquartile range, and discrepancies are expressed with percentage and numerical values. Kolmogorov–Smirnov was used to determine whether the data showed normal distribution; Student t-test was used for the differences between the two groups (patients with and without unintentional discrepancies) for continuous variables that provided normal distribution, and Mann Whitney U test was used for continuous variables that did not provide normal distribution. Chi-square and Fisher Exact tests were preferred for variables that showed and did not show normal distribution, respectively. Missing data was excluded from the analysis. $P < 0.05$ was accepted as the statistical significance level. In our study, statistical analyses were performed using Jamovi version 1.6 omputer software.

Results

A total of 300 patients were examined during the study, of whom 105 were admitted to the pediatric general ward and included in the analysis (Fig. 1). Of these, 50 (47.6%) were female and 55 (52.4%) male, with a median age of 62.3 months (IQR 5–100). The study population consisted of 43 infants (41%), 45 children (42.9%), and 17 adolescents (16.1%). Baseline demographic characteristics are presented in Table 1. Patients with unintentional discrepancies significantly differed from those without in terms of number of comorbidities, hospital stay, ICU admission, and total number of medications (Table 1).

Most patients (75.2%, $n = 79$) were admitted from the emergency department, followed by outpatient clinics (21.9%, $n = 23$) and the surgical ward (2.9%, $n = 3$). During the study period, 31 patients required ICU admission. Patient transfer processes are summarized in Table 2.

Table 3 summarizes the most frequently prescribed medications. Most patients were admitted for lower respiratory tract infections, making budesonide and salbutamol the most used medications. Other frequently used treatments included antibiotics (ampicillin-sulbactam, ceftriaxone) and supportive agents such as methylprednisolone, vitamin D, and inhaled adrenaline.

Table 1 Characteristics of patients ($n=105$)

	Total 105 (100%)	Patients with UMD 25 (23.8%)	Patients without UMD 80 (76.19%)	p
Sex, n (%)				> 0,05
Female	50 (47.61%)	13 (12.38%)	37 (35.23%)	
Male	55 (52.38%)	12 (11.42%)	43 (40.95%)	
Age (months), mean ± SD	62.3 ± 61.3	77 ± 60.6	57.7 ± 61.1	> 0.05
Weight (kg), mean ± SD	21.5 ± 21	21.2 ± 13.8	21.6 ± 22.9	> 0.05
Height (cm), mean ± SD	103 ± 37.6	107 ± 35	102 ± 38.6	> 0.05
No of comorbidities per patient ± SD	0.75 ± 0.98	1.4 ± 1.12	0.55 ± 0.85	**< 0.001**
Most common comorbidities, n (%)				> 0.05
Cystic fibrosis	10 (9.52%)	5 (4.76%)	5 (4.76%)	
Epilepsy	9 (8.57%)	7 (6.66%)	2 (1.9%)	
Asthma	7 (6.66%)	2 (1.9%)	5 (4.76%)	
Diabetes mellitus	7 (6.66%)	-	7 (6.66%)	
Spinal muscular atrophy	5 (4.76%)	1 (0.95%)	4 (3.8%)	
No of Comorbidities, n (%)				**< 0.001**
1	30 (28.57%)	9 (8.57%)	21 (20%)	
2	8 (7.61%)	4 (3.8%)	4 (3.8%)	
3	11 (10.47%)	6 (5.71%)	5 (4.76%)	
Mean length of hospital stays (day) ± SD	8.39 ± 4.32	10.2 ± 5.56	7.84 ± 3.73	**0.037**
Causes of hospitalization, n (%)				> 0.05
Infection diseases	77 (73.33%)	19 (18.09%)	58 (55.23%)	
Neurological diseases	9 (8.57%)	3 (2.85%)	6 (5.71%)	
Endocrinological diseases	8 (7.61%)	-	8 (7.61%)	
Surgery	6 (5.71%)	2 (1.9%)	4 (3.8%)	
Admission to intensive care, n (%)	31 (29.52%)	12 (11.42%)	19 (18.09%)	**0.02**
Number of drugs per patient, mean ± SD	8.35 ± 5.56	11.5 ± 6.28	7.38 ± 4.97	**0.003**

SD Standard derivation, *UMD* Unintentional medication discrepancies

Medication discrepancies were identified in 25 patients, amounting to 518 discrepancies overall. Of these, 471 (90.9%) were intentional and 47 (9.1%) unintentional (Table 4). The overall discrepancy rate decreased from 85% at admission to 15% during transitions. According to the MedTax classification, most unintentional discrepancies ($n=38$, 80.9%) were complete, predominantly drug

Table 2 Inter-departmental transfer processes of the patients in hospital ($n=105$)

	Total ($n=105$)	Patients with UMD ($n=25$)	Patient without UMD ($n=80$)	*p*
ED-GW-Discharge	59 (%56.1)	9 (%8.57)	50 (%47.61)	> 0.05
EM-PICU-GW-Discharge	15 (%14.28)	5 (%4.76)	10 (%9.52)	
ED-GM-PICU-GW-Discharge	4 (%3.8)	3 (%2.85)	1 (%0.95)	
ED-GM-PICU-Discharge	1 (%0.95)	-	1 (%0.95)	
OP-GW-Discharge	15 (%14.28)	4 (%3.8)	11 (%10.47)	
OP-PICU-GW-Discharge	6 (%5.71)	2 (%1.9)	4 (%3.8)	
OP-GW-PICU-GW-Discharge	2 (%1.9)	1 (%0.95)	1 (%0.95)	
Surgery-PICU-GW-Discharge	3 (%2.85)	1 (%0.95))	2 (%1.9)	

ED Emergency department, *GW* General ward, *OP* Outpatient, *PICU* Pediatric intensive care unit, *UD* Unintentional medication discrepancies

Table 3 The most commonly prescribed medications

	n
Budesonide	65
Salbutamol	58
Methylprednisolone	42
Vitamin D3 (Cholecalciferol)	38
Ampicillin-Sulbactam	32
Adrenaline (inhaled)	31
Ceftriaxone	31
Magnesium	27
Paracetamol	25
Pantoprazole	24
Zinc	21
Ipratropium	19
Ibuprofen	18

Table 4 Identified medication discrepancies among patients included in the study

No of participants, n (%)	**105 (100%)**
Number of patients with unintentional medication discrepancies, n (%)	25 (23.8%)
Number of medication discrepancies, n (%)	518 (100%)
Number of intentional medication discrepancies, n (%)	471 (90.93%)
Number of unintentional medication discrepancies, n (%)	47 (9.07%)
Mean number of medication discrepancies during admission ± SD	4.93 ± 3.32
Mean number of intentional medication discrepancies ± SD	4.49 ± 3.04
Mean number of unintentional medication discrepancies ± SD	0.44 ± 0.98

omissions ($n = 37$), with one duplication. The remaining nine (19.1%) were partial discrepancies (Table 5). Three cases (6.4%) could not be fully categorized within MedTax and were difficult to categorize using the existing MedTax structure. These discrepancies were classified according to consensus.

In total, discrepancies involved 28 different medications. Proton pump inhibitors ($n = 5$) were the most frequently implicated, followed by vitamin D ($n = 4$), montelukast ($n = 4$), and the antiepileptics levetiracetam ($n = 3$) and oxcarbazepine ($n = 2$). When grouped, vitamins (multivitamins and vitamin D) accounted for the highest number of discrepancies ($n = 6$). Additional discrepancies were observed with sucralfate, dornase alfa, pancreatin, and cetirizine (each $n = 2$).

Table 5 Partial medication discrepancies between best possible medication history and drugs ordered at transition of care, and their classification according to MedTax [26]

Drugs on best possible medication history list	Drugs ordered at transition of care	MedTax classification
Progas® (Pantoprazole) 40 mg flakon 2*30 mg**	Pantactive® (Pantoprazole) 40 mg film tablet 1*40 mg	2.1.4. Different brand name but same generic name*
Keppra® (Levetiracetam) 100 mg/ml solution 2*300 mg (3 ml)	Keppra®(Levetiracetam) 1000 mg tablet 2*300 mg	2.2.3. Different strength and different total daily dose*
Trileptal® (Oxcarbazepine) 60 mg/ml solution 2*90 mg (1.5 ml)	Trileptal® (Oxcarbazepine) 300 mg film coated tablet 2*90 mg	2.2.4 Different strength but same total daily dose*
Kreon® (pancreatin) 25000IU enteric coated capsule 5*25000IU	Kreon® (pancreatin) 25000IU enteric coated capsule 1*25000IU	2.2.11 Same strength and same number of units but different frequency different total daily dose
Lioseral® (Baclofen) 10 mg tablet at a dose 15 mg in morning 15 mg at noon and 5 mg at night	Lioseral® (Baclofen) 10 mg tablet 2*15 mg	2.2.12. Same strength but different frequency and different number of units and different total daily dose
Keppra® (Levetiracetam) 300 mg film coated tablet 2*600 mg	Keppra® (Levetiracetam) 300 mg film coated tablet 2*300 mg	2.2.14 Same strength and same frequency but different number of units and different total daily dose
Epixx® (Levetiracetam) 100 mg/ml solution 2*200 mg (2 ml)	Epixx® (Levetiracetam) 100 mg/ml solution 2*150 mg (1.5 ml)	2.2.14 Same strength and same frequency but different number of units and different total daily dose
Prednol-L (Methylprednisolone) 250 mg flacon 1*1000 mg	Prednol-L (Methylprednisolone) 250 mg flacon 1*500 mg	2.2.14 Same strength and same frequency but different number of units and different total daily dose

*This discrepancy was classified based on the consensus; however, there was debate about whether it could be categorized under "2.3.5. Different dosage form but same route of administration

**Same discrepancy seen in two patients

Discussion

Our study identified 518 medication discrepancies that were identified in pediatric patients, with 471 (90.93%) classified as intentional and 47 (9.07%) as unintentional. This distinction between intentional and unintentional discrepancies is crucial, as highlighted by Almanasreh et al., with unintentional discrepancies being recognized as medication errors [26]. However, this distinction has not yet been fully implemented in the MedTax classification system, potentially complicating the accurate categorization and management of medication discrepancies. MedTax has the potential to enhance MedRec processes by improving detection, classification, and data exchange when integrated into electronic health record (EHR) systems. However, one significant challenge lies in the issue of excessive alerts generated by such systems. A survey found that 87% of primary care physicians (PCPs) reported receiving excessive alerts, with a median of 63 alerts daily, and more than two-thirds feeling overwhelmed by the volume [32]. This phenomenon, known as alert fatigue, can lead to the dismissal of both critical and trivial notifications, thereby reducing system effectiveness and contributing to clinician burnout [33].

Although MedTax provides a detailed framework for classifying medication discrepancies, we believe that it may benefit from further refinement to better distinguish between intentional and unintentional discrepancies. Such improvements would not only enhance classification accuracy but also strengthen patient safety, particularly in healthcare systems already burdened by excessive notifications.

In this study, 22.8% of pediatric patients had unintentional medication discrepancies at hospital admission, a rate notably lower than the 60% reported in adult populations [12]. Discrepancy rates in pediatric patients range from 6.1% to 63%, with our findings placed within this range [5, 11–15]. In comparison, Farha et al. reported a lower rate of 13%, likely due to fewer medications per patient in our study, while UK studies reported a 53.4% discrepancy rate, with half of the patients on chronic medications, compared to only one-third in our study [12, 15]. Similarly, a study with a 63% discrepancy rate had an average of 4.3 medications per patient before admission, compared to our lower rate of 1.34, which may explain the lower discrepancy rate we observed [34].

Medication discrepancies in children with chronic diseases range from 5 to 63%, influenced by treatment complexity, the number of medications, and high-risk

drug groups [35, 36]. Discrepancy rates vary across conditions, including 28.4% in neurological diseases, 17% in oncology, 8.8% in renal, 7.6% in cardiovascular, and 5% in gastrointestinal diseases, with epilepsy reaching 63% [35, 36]. These findings suggest certain disease groups are more prone to discrepancies. Hospitalization increases medication use significantly, contributing to higher discrepancies during admission than interdepartmental transitions [5, 35]. In our study, the discrepancy rate dropped from 85% at admission to 15% during transitions. This variation may reflect differences in clinical settings, as our research was conducted in a tertiary care hospital, while other studies involved different environments. Limited interdepartmental transitions and emergency department admissions in our sample may also explain this difference.

Further studies with larger sample size are needed to validate the utility of MedTax in pediatric settings and to ensure its adaptability across diverse clinical contexts and patient populations, such as medication reconciliation at discharge, NICU, PICU, emergency, and hematology units, where patients' needs and knowledge levels differ [37]. Particularly given the limited real-world validation of MedTax, its application requires further refinement.

In our study, 38 out of 47 medication discrepancies were drug mismatches, with medication omission being the most common discrepancy (78.8%) as reported in many studies [5, 35, 36]. Additionally, 19.5% of the discrepancies involved drugs with partial mismatches. Of the 47 identified medication discrepancies, a small proportion (6.38%, $n = 3$) posed challenges in classification and were difficult to categorize using the existing MedTax structure. The hierarchical structure of the MedTax taxonomy, which classifies discrepancies starting from the drug name and extending to drug administration and duration of therapy, poses challenges. Notably, the MedTax system classifies each medication discrepancy into only one category, even when it could potentially fall into multiple categories.

As an example, a pediatric patient initially prescribed oxcarbazepine suspension (Trileptal® 60 mg/ml) experienced a discrepancy when switched to the equivalent dosage in tablet form (Trileptal® 300 mg tablet) during hospitalization. This situation could be classified under both "*Different strength but same total daily dose*" and "*Different dosage form but same route of administration*". Such discrepancies, particularly in pediatric settings where suitable formulations may not be available, illustrate the need for a taxonomy that can account for changes in dosage form as well as dosage strength. While the taxonomy provides guidelines for addressing changes in strength without comparing frequency or dosage units, it does not sufficiently account for cases where the dosage form changes, leading to a potential overreporting of discrepancies.

In our study, discrepancies involving changes in the brand name of medications, such as Progas® (pantoprazole 40 mg vial) and Pantactive® (pantoprazole 40 mg tablet), highlight an important nuance in medication reconciliation. While the brand names differ, the generic component remains the same. However, the clinical significance of such discrepancies varies depending on the dosage form and the patient's specific needs. For example, in enterally fed patients, using a tablet form of pantoprazole instead of its appropriate formulation, such as parenterally, could result in complications like tube occlusion [38]. In contrast, a change in the brand name alone without altering the formulation is less likely to lead to significant clinical outcomes [39].

MedTax's current taxonomy does not fully account for the varying degrees of clinical impact associated with discrepancies involving brand name changes versus those involving dosage form changes. Classifying discrepancies solely based on brand name variations may overestimate their clinical importance. Conversely, discrepancies involving formulation changes, particularly when they affect administration via specific routes (e.g., nasogastric tubes), often carry greater clinical risk and demand prioritization. For instance, administering tablet formulation inappropriately through a nasogastric tube can lead to patient harm, underscoring the critical need to recognize and address formulation-related discrepancies more distinctly.

These findings emphasize the limitations of MedTax in addressing the complex interplay between medication name, dosage form, and clinical context. The observed discrepancy between Progas® and Pantactive® illustrates that the current taxonomy lacks the granularity needed to differentiate discrepancies based on their potential clinical impact. This limitation suggests the need for a more refined hierarchical structure within MedTax. A modified system should incorporate considerations such as formulation changes, route-specific administration issues, and clinical consequences. Doing so would improve its ability to classify and prioritize discrepancies based on their actual risk to patient safety.

By expanding MedTax to better capture clinically significant discrepancies, such as those involving inappropriate dosage forms for specific administration routes, healthcare providers can more effectively identify and address medication errors that pose substantial risks to patients. This refinement would not only enhance the utility of MedTax but also contribute to improved medication safety practices in diverse clinical settings.

In the taxonomy, strength is defined as the amount of drug per unit of dosage form (e.g., Lipitor® Atorvastatin 10 mg). However, in pediatric patients, due to the

unavailability of a formulation that matches the appropriate dose for the child's weight, a different drug strength may be used. Consequently, evaluating medication discrepancies in pediatric patients based solely on strength may lead to misclassification of discrepancies. Instead, we suggest classifying discrepancies based on dose rather than strength for at least pediatric patients.

The MedTax system includes criteria such as "*wrong or unclear dose*" to identify complex errors, such as unusual drug strengths or unavailable routes, which require specialized pharmaceutical knowledge. Evaluating whether a dose is incorrect involves more than comparing it to standard guidelines; it requires considering the patient's clinical condition, including factors such as age, weight, comorbidities, and other medications. As Almanasreh et al. noted, this presents challenges for healthcare professionals who lack the necessary expertise. Our study was conducted in a teaching hospital where resident physicians have varying levels of experience. Individual patient differences can lead to the overlooking of critical patient-specific factors, contributing to unintentional medication discrepancies [40]. Despite these limitations, MedTax remains a valuable tool for medication reconciliation, especially during ToC, offering significant potential to enhance medication safety.

MedRec has proven effective when integrated into healthcare curricula, but training in this area is often inconsistent [41, 42]. We believe that non-pharmacists may struggle with accurately applying MedTax, highlighting the need for targeted training for other healthcare personnel. The uneven integration of patient safety topics into pharmacy education, especially in developing countries where curricula often focus on traditional pharmacy roles, contributes to this issue. Consequently, efforts to standardize and expand patient safety education across pharmacy programs remain limited [42].

To overcome these challenges and improve the effectiveness of MedTax, it could benefit from adopting a more detailed hierarchical structure similar to that of The Pharmaceutical Care Network Europe (PCNE) classification system, which is well-validated and reliable for categorizing drug-related problems [43]. By incorporating categories for problems, causes, interventions, and status, the system would improve the reporting, classification, and tracking of medication discrepancies, leading to a more comprehensive approach.

Limitations

Findings should be interpreted in the context of the following limitations. Data collection was carried out by a single individual, which may introduce a bias in the interpretation of results. The pharmacist involved in the study was completing a pharmacy master's degree, and results may differ with a more experienced professional. The study also had a small sample size, and replication with coders from more diverse clinical and nonclinical backgrounds is recommended. As a single-center study, the findings may not fully represent the broader diversity of regional or general populations. Furthermore, the cross-sectional design's limited time frame restricts the ability to observe changes over time, which may lead to potentially misleading conclusions.

Conclusion

To the best of our knowledge, this is the first study to evaluate the feasibility of the MedTax classification system for identifying medication discrepancies in pediatric patients. Our findings demonstrate that while MedTax can be adapted to pediatric settings, there are limitations in its ability to account for certain discrepancies, such as those involving changes in dosage form or brand name, which may impact patient safety. To enhance its utility, further refinement of MedTax is needed, particularly to improve its ability to distinguish between discrepancies with varying clinical significance. These improvements are essential for ensuring more accurate medication reconciliation, especially in pediatric and specialized clinical settings. Future research should validate the findings in larger, diverse populations and explore the integration of MedTax with electronic health record systems to optimize medication safety.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12887-025-06275-3.

Supplementary Material 1.

Supplementary Material 2.

Acknowledgements

None.

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Berre Mercümek, Muhammed Yunus Bektay, Selçuk Uzuner and Fikret Vehbi İzzettin. The first draft of the manuscript was written by Berre Mercümek and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding

This research received no external funding.

Data availability

All data generated or analyzed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Clinical Research of Bezmialem Vakif University with the decision number of 11/5.

As all participants were under 18 years of age, written informed consent was obtained from their parents or legal guardians. Assent from the participants themselves was also obtained whenever appropriate.

Competing interests
The authors declare no competing interests.

Clinical trial number
Not applicable.

Author details
[1]Department of Clinical Pharmacy, Institute of Health Sciences, Bezmialem Vakif University, Istanbul, Turkey
[2]Department of Clinical Pharmacy, Faculty of Pharmacy, Bezmialem Vakif University, Istanbul, Turkey
[3]Department of Clinical Pharmacy, Faculty of Pharmacy, Istanbul University-Cerrahpaşa, Istanbul, Turkey
[4]Department of Pediatrics, Istanbul Medipol University, Istanbul, Turkey

Received: 27 September 2024 / Accepted: 6 October 2025
Published online: 04 November 2025

References

1. Aranha GA, Cruz AC, Pedreira MdaLG. Medication reconciliation in pediatrics: a validation of instruments to prevent medication errors. Rev Bras Enferm. 2023;76:e20210755. https://doi.org/10.1590/0034-7167-2021-0755.
2. World Health Organization. Medication without harm: policy brief. Geneva; 2023. https://www.who.int/publications/i/item/9789240062764. Accessed 16 Sept 2024.
3. Gök D, Yıldırım SH. Medication errors and reporting in pediatrics. J Behcet Uz Childrens Hospital. 2016;6:165–73. https://doi.org/10.5222/BUCHD.2016.165.
4. Işık MN, Dalgıç N, Okuyan B, Yıldırmak ZY, Sancar M. Medication review for hospitalized pediatric patient: clinical pharmacist interventions. J Pediatr Infect. 2020;54:237–43. https://doi.org/10.5578/ced.69774.
5. Iturgoyen Fuentes DP, Martin-Aragon S, Cuervas-Mons VM. Medication reconciliation upon admission in paediatric hospital setting: preliminary data. Int J Clin Pharm. 2020;42:209–16. https://doi.org/10.1007/S11096-019-00962-9/TABLES/2.
6. D'Errico S, Zanon M, Radaelli D, Padovano M, Santurro A, Scopetti M, et al. Medication errors in pediatrics: proposals to improve the quality and safety of care through clinical risk management. Front Med (Lausanne). 2022;8:814100. https://doi.org/10.3389/FMED.2021.814100/BIBTEX.
7. Dahmash DT, Shariff ZB, Kirby DJ, Terry D, Huynh C. Literature review of medication administration problems in paediatrics by parent/caregiver and the role of health literacy. BMJ Paediatr Open. 2020. https://doi.org/10.1136/BMJPO-2020-000841.
8. Patel S, Kolte S, Magdalia H, Bhatt S, Patel R. Liquid medication dosing error amongst parents/ caregivers at outpatient clinic. Indian J Pharm Pract. 2022;15:235–43. https://doi.org/10.5530/ijopp.15.3.42.
9. Lopez-Pineda A, de Gonzalez Dios J, Guilabert Mora M, Mira-Perceval Juan G, Mira Solves JJ. A systematic review on pediatric medication errors by parents or caregivers at home. Expert Opin Drug Saf. 2021;21:95–105. https://doi.org/10.1080/14740338.2021.1950138.
10. World Health Organization. Medication safety in transitions of care. Geneva; 2019. https://www.who.int/publications/i/item/WHO-UHC-SDS-2019.9. Accessed 16 Sept 2024.
11. Tamiru A, Edessa D, Sisay M, Mengistu G. Magnitude and factors associated with medication discrepancies identified through medication reconciliation at care transitions of a tertiary hospital in eastern Ethiopia. BMC Res Notes. 2018;11:1–7. https://doi.org/10.1186/S13104-018-3668-Z/TABLES/3.
12. Huynh C, Tomlin S, Jani Y, Solanki GA, Haley H, Smith RE, et al. An evaluation of the epidemiology of medication discrepancies and clinical significance of medicines reconciliation in children admitted to hospital. Arch Dis Child. 2016;101:67–71. https://doi.org/10.1136/ARCHDISCHILD-2015-308591.
13. dos Alcântara TS, de Araújo Neto FC, Lima HF, de Araújo DCSA, Sanchez JM, Aires-Moreno GT, et al. Prevalence of medication discrepancies in pediatric patients transferred between hospital wards. Int J Clin Pharm. 2021;43:909–17. https://doi.org/10.1007/S11096-020-01196-W/TABLES/4.
14. Blaine K, Wright J, Pinkham A, O'Neill M, Wilkerson S, Rogers J, et al. Medication order errors at hospital admission among children with medical complexity. J Patient Saf. 2022;18:E156–62. https://doi.org/10.1097/PTS.0000000000000719.
15. Abu Farha R, Abu Hammour K, Al-Jamei S, Alqudah R, Zawiah M. The prevalence and clinical seriousness of medication discrepancies identified upon hospital admission of pediatric patients. BMC Health Serv Res. 2018. https://doi.org/10.1186/s12913-018-3795-1.
16. da Alves Costa F, van Mil JWF, Alvarez-Risco A. The Pharmacist guide to implementing pharmaceutical care. Springer International Publishing; 2019. https://doi.org/10.1007/978-3-319-92576-9.
17. Decourcey DD, Silverman M, Chang E, Ozonoff A, Stickney C, Pichoff D, et al. Medication reconciliation failures in children and young adults with chronic disease during intensive and intermediate care. Pediatr Crit Care Med. 2017;18:370–7. https://doi.org/10.1097/PCC.0000000000001090.
18. Stolldorf DP, Ridner SH, Vogus TJ, Roumie CL, Schnipper JL, Dietrich MS, et al. Implementation strategies in the context of medication reconciliation: a qualitative study. Implement Sci Commun. 2021;2:1–14. https://doi.org/10.1186/S43058-021-00162-5/TABLES/2.
19. World Health Organization. High 5s- Standard operating procedures. World Health Organization; 2013. https://www.who.int/initiatives/high-5s-standard-operating-procedures. Accessed 16 Sept 2024.
20. dos Alcântara TS, Lima HF, Valença-Feitosa F, Aires-Moreno GT, dos Santos GA, Araujo DC, et al. Development and implementation of a medication reconciliation during pediatric transitions of care in a public hospital. J Am Pharm Assoc (2003). 2022;62:1400-1406.e3. https://doi.org/10.1016/J.JAPH.2021.12.009.
21. Van Nguyen A, Romanowski G, Ley M, Lim E, McFarland K, Morrison T. Admission medication reconciliations in pediatric patients admitted to an inpatient psychiatry unit. J Pediatr Pharmacol Ther. 2022;27:443–6. https://doi.org/10.5863/1551-6776-27.5.443.
22. Almanasreh E, Moles R, Chen TF. The medication reconciliation process and classification of discrepancies: a systematic review. Br J Clin Pharmacol. 2016;82:645–58. https://doi.org/10.1111/BCP.13017.
23. Claeys C, Nève J, Tulkens PM, Spinewine A. Content validity and inter-rater reliability of an instrument to characterize unintentional medication discrepancies. Drugs Aging. 2012;29:577–91. https://doi.org/10.1007/BF03262275.
24. Hohmann C, Eickhoff C, Klotz JM, Schulz M, Radziwill R. Development of a classification system for drug-related problems in the hospital setting (APS-Doc) and assessment of the inter-rater reliability. J Clin Pharm Ther. 2012;37:276–81. https://doi.org/10.1111/J.1365-2710.2011.01281.X.
25. Smith JD, Coleman EA, Min SJ. A new tool for identifying discrepancies in postacute medications for community-dwelling older adults. Am J Geriatr Pharmacother. 2004;2:141–8. https://doi.org/10.1016/S1543-5946(04)90019-0.
26. Almanasreh E, Moles R, Chen TF. The medication discrepancy taxonomy (MedTax): the development and validation of a classification system for medication discrepancies identified through medication reconciliation. Res Social Adm Pharm. 2020;16:142–8. https://doi.org/10.1016/j.sapharm.2019.04.005.
27. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008;61:344–9. https://doi.org/10.1016/J.JCLINEPI.2007.11.008.
28. Al-Hashar A, Al-Zakwani I, Eriksson T, Sarakbi A, Al-Zadjali B, Al Mubaihsi S, et al. Impact of medication reconciliation and review and counselling, on adverse drug events and healthcare resource use. Int J Clin Pharm. 2018;40:1154–64. https://doi.org/10.1007/S11096-018-0650-8.
29. Kabir R, Liaw S, Cerise J, Yi J, Mulvany C, Qiu M, et al. Obtaining the best possible medication history at hospital admission: description of a pharmacy technician-driven program to identify medication discrepancies. J Pharm Pract. 2023;36:19–26. https://doi.org/10.1177/08971900211021254/ASSET/IMAGES/LARGE/10.1177_08971900211021254-FIG2.JPEG.
30. Chan C, Woo R, Seto W, Pong S, Gilhooly T, Russell J. Medication reconciliation in pediatric cardiology performed by a pharmacy technician: a prospective cohort comparison study. Can J Hosp Pharm. 2015;68:8. https://doi.org/10.4212/CJHP.V68I1.1419.
31. El OA, Karaoui LR, Chamoun N, Assi C, Yammine K, Ramia E. Value of pharmacy services upon admission to an orthopedic surgery unit. J Pharm Policy Pract. 2021;14:103. https://doi.org/10.1186/S40545-021-00384-X.
32. Singh H, Spitzmueller C, Petersen NJ, Sawhney MK, Sittig DF. Information overload and missed test results in electronic health record-based settings. JAMA Intern Med. 2013;173:702–4. https://doi.org/10.1001/2013.JAMAINTERNMED.61.

33. McGreevey JD, Mallozzi CP, Perkins RM, Shelov E, Schreiber R. Reducing alert burden in electronic health records: state of the art recommendations from four health systems. Appl Clin Inform. 2020;11:1–12. https://doi.org/10.1055/S-0039-3402715.
34. Hovey SW, Click KW, Jacobson JL. Effect of a pharmacist admission medication reconciliation service at a children's hospital. J Pediatr Pharmacol Ther. 2023;28:36–40. https://doi.org/10.5863/1551-6776-28.1.36.
35. Cuervas-Mons Vendrell M, Iturgoyen Fuentes DP, Arrojo Suárez J, Jimenez Lozano I, Fernandez-Llamazares CM, Tristancho-Perez A, et al. Medication reconciliation on admission in paediatric chronic patients: a multicentre study. Anales de Pediatría (English Edition). 2023;99:376–84. https://doi.org/10.1016/J.ANPEDE.2023.11.008.
36. Louiselle K, Harte L, Thompson C, Pabst D, Calvert A, Patterson ME. Medication discrepancy risk factors for pediatric patients with epilepsy at hospital admission. J Pediatr Pharmacol Ther. 2021;26:384–94. https://doi.org/10.5863/1551-6776-26.4.384.
37. Seniwati T, Rustina Y, Nurhaeni N, Wanda D. Patient and family-centered care for children: a concept analysis. Belitung Nurs J. 2023;9:17. https://doi.org/10.33546/BNJ.2350.
38. García González D, Martín-Suárez A, Salvador Sánchez JJ, Sánchez Serrano JÁ, Calvo MV. Medication delivery errors in outpatients with percutaneous endoscopic gastrostomy: effect on tube feeding replacement. Sci Rep. 2023;13:1–8. https://doi.org/10.1038/s41598-023-48629-w.
39. Desai RJ, Sarpatwari A, Dejene S, Khan NF, Lii J, Rogers JR, et al. Comparative effectiveness of generic and brand-name medication use: a database study of US health insurance claims. PLoS Med. 2019;16:e1002763. https://doi.org/10.1371/JOURNAL.PMED.1002763.
40. Park J, Kim AJ, Cho EJ, Cho YS, Jun K, Jung YS, et al. Unintentional medication discrepancies at care transitions: prevalence and their impact on post-discharge emergency visits in critically ill older adults. BMC Geriatr. 2024;24:1–8. https://doi.org/10.1186/S12877-024-05517-W/TABLES/3.
41. Ramjaun A, Sudarshan M, Patakfalvi L, Tamblyn R, Meguerditchian AN. Educating medical trainees on medication reconciliation: a systematic review Curriculum development. BMC Med Educ. 2015;15:1–9. https://doi.org/10.1186/S12909-015-0306-5/TABLES/1.
42. El-Awaisi A, Koummich S, Koraysh S, El Hajj MS. Patient safety education in entry to practice pharmacy programs: a systematic review. J Patient Saf. 2022;18:E373–86. https://doi.org/10.1097/PTS.0000000000000818.
43. Pharmaceutical Care Network Europe Association. PCNE Classification for Drug-Related Problems V9.1. 2020.

Publisher's Note