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Abstract

Objectives: To evaluate the nature and frequency of medication errors resulting from the use of a computerized provider order-entry (CPOE) system in a pediatric department.

Methods: We conducted a retrospective study to examine errors related to computerized orders using the software Pharma® (Computer Engineering, France) in pediatric department between 31/05/2015 to 01/12/2015**.** These errors were signaled by pharmacists who examine CPOEs daily.

Results: A total of 302 pharmacist interventions (PharmInt) were carried out by clinical pharmacists during the study period. Of the 302 PharmInts, a total of 95 (31.5%) contained no data on the patient's bodyweight, which should have been provided by the prescriber (Table 1). After the PharmInt, information on bodyweight was then provided in 47 of these cases (15.6%). Incomplete information about administration frequency accounted for 19.9% of total PharmInts. Prescribing an excessive dose occurred in 17.6% of PharmInts, inappropriate modifications of prescription unit accounted for 9.9% of PharmInts, and incorrect dosage was prescribed in 8.3% of PharmInts. Of the 302 PharmInts, 255 concerned prescription errors and bodyweight missing not provided after PharmInt. Paracetamol, in its different forms (injectable, solid or liquid oral forms) accounted for 35.7% of total PharmInts. Noted errors for paracetamol included an incorrect dosage form, co-administration of two paracetamol-containing drugs, modification of the prescription unit, incorrect frequency of administrations, and absence of the patient's bodyweight. Inconsistent use of a contradicted or a non-used drug for pediatric patients was noted along with prescriptions for inadequate dosages.

Discussion and conclusion: Our work revealed several error types in prescribing for pediatric patients, mainly absence of bodyweight, incorrect frequency of administration and excessive

doses. Information on bodyweight is crucial in pediatric patients: our study highlights the need to make it mandatory to complete prescriptions via CPOE systems.

The role of better software design is pivotal to avoiding these errors. In addition to optimizing the quality of CPOE-entries, well-designed software, better-trained users, and improved communication among healthcare will reduce errors.

Introduction

Medication errors are a major source of risk and injury to patients, especially pediatric patients [1,2]. The disadvantages of handwritten orders include illegibility, the time-consuming process for pharmacy approval, and an absence of immediate notification systems regarding drug interactions and misuse [3,4]. Hence, the replacement of handwritten orders by the computerized provider order-entry (CPOE) system is increasingly used in hospitals and health-care centers [5,6]. Indeed, the use of CPOE provides undisputable advantages, such as the elimination of illegibility problems and the ability to include notification systems that assist in the prescription process [7]. Nevertheless, data regarding errors resulting from CPOE are frequently reported, especially when the system is initially implemented [8,9]. Moreover, it has been noted that these errors can occur at any stage within the therapy management, including prescribing, dispensing, administering, and monitoring [8]. The reasons behind such errors are in part due to various technical reasons such as confusing software, a screen overload as well as human-related issues such as lack of experience and training, cognitive overload or depersonalization between healthcare actors, as face to face communication is replaced by computer accessibility [10,11]. During the last decade, errors resulting from recently implemented CPOE systems have been reported in many worldwide studies, including France [10,11,12,13]. Our study focused on the errors that occur when CPOE is used to prescribe drugs to pediatric patients. Hence, we researched and noted all pharmacist interventions (PharmInts) that involved different errors in prescriptions for pediatric patients over a 6-month period. The nature and frequency of these errors, and the drugs concerned noted in the PharmInt, were analyzed to evaluate the efficiency of the CPOE systems for pediatric use.

Methods

We performed a retrospective study that noted errors related to computerized orders carried out by the software Pharma® (Computer Engineering, France) in pediatric department between 31/05/2015 and 01/12/2015**.** Pharma® computerizes various steps within the therapy management, including prescription, pharmaceutical approval, and administration by the nursing staff. Interestingly, this CPOE system allows prescribers, pharmacists, and nursing staff to share notices, opinions, and various decisions on interventions.

Prescribers are trained periodically after the implementation of CPOE in clinical departments. These training courses are offered but not imposed, to all prescribers every 6 months. A total of 924 patients were admitted into the pediatric department and registered into Pharma® during the study period. The patients' characteristics are presented in Figure 1. Prescriptions are made informatically by prescribers using Pharma®. Each patient has an account that is created by the hospital entry office where information such as the patient's name and age are found. When physicians prescribe, they must mention patient's bodyweight and choose appropriate medications. Prescribers then choose those medications from the list of drugs proposed by the CPOE software.

Clinical pharmacists who use CPOE daily gave their approval when no prescription errors were found. In other cases, clinical pharmacists realized a PharmInt that needed to be read by the prescriber and/or nursing staff. Such a PharmInt was formulated as a "Memo" when it concerned a general remark, such as in the case of the absence of a patient's bodyweight. The PharmInt could also be formulated as a pharmaceutical opinion related to the prescribed drug. The pharmaceutical opinions were evaluated and then validated by the prescriber(s). When necessary, pharmacists could suspend drug delivery or request modifications of a prescription with the prescriber(s) consent.

Results

A total of 1297 computerized orders containing 4722 prescriptions were assessed by the pediatric department. From these prescriptions, a total of 302 pharmacist interventions (PharmInts) were carried out by clinical pharmacists (6.4%, Table 1, Figure 2). Of the 302 PharmInts, a total of 95 (31.5%) contained no data on the patient's bodyweight, which should have been provided by the prescriber (Table 1). After the PharmInt, information on bodyweight was then provided in 47 of these cases (15.6%); however, in the other 48 cases (15.9%), the information on bodyweight was never provided despite the PharmInt.

Errors related to administration frequency of drugs such as paracetamol and phloroglucinol prescribed as to be "used when needed", accounted for 19.9% of total PharmInts (Table 1). For example, if physicians prescribe only 4 times daily without mentioning the precise interval, it is considered as a frequency administration error by the pharmacist. Prescribing an excessive dose occurred in 17.6% of PharmInts, inappropriate modifications of prescription unit accounted for 9.9% of PharmInts and incorrect dosage form for 8.3% of PharmInts (Table 1). PharmInts that highlighted the prescription of a contraindicated drug, the need for treatment monitoring, and/or the risk of a drug-drug interaction accounted for 4%, 3.3%, and 3.3 % of PharmInts, respectively (Table 1). Errors relating to incorrect dosing regimens and an absence of treatment duration were found in 1.3% and 1% of total PharmInts, respectively (Table 1).

Of the 302 PharmInts, 255 concerned prescription errors and bodyweight missing not provided after PharmInt. Table 2 lists the drugs that were subject to 255 PharmInts and the errors associated with their prescriptions. Paracetamol (in its different forms: injectable, solid or liquid oral forms) was the main drug concerned and accounted for 36.3% of total PharmInts. Noted errors for this drug included an incorrect dosage form, co-administration of two paracetamol-containing drugs, modification of a prescription unit, errors in the

frequency of administrations, or the absence of bodyweight data. Phloroglucinol and esomeprazole that appeared in PharmInts were mainly related to modifications to the prescription unit and inconsistent dosages. Notably, drugs presented in liquid oral forms, such as antibiotics or antipyretics, were frequently prescribed with modified prescription units. This was exemplified by paracetamol, which is habitually prescribed in dose-kg mode whereas some prescribers changed this to milliliter or milligram mode. This was also noted within two prescriptions for dalteparine, where prescribers used "UI anti-Xa" instead of "syringe", inserting a dose of 1 UI anti-Xa/day in the prescription instead of 1 syringe/day (each syringe contains 2500 UI anti-Xa). As noted in Table 2, inconsistent use of contradicted or non-used drugs for pediatric patients was noted for drugs such as ketoprofene (Profenid®, Bi-profenid®), dorzolamide /timolol eye drops (Cosopt®), S*accharomyces boulardii* (Ultralevure®), dexamethasone/oxytetracycline (Sterdex®), and trimebutine (Debridat®). The prescription of inadequate dosage to pediatric patients, such as injectable paracetamol 1000 mg/100 mL instead of 500 mg/50 mL, or injectable methylprednisolone 120 mg, were also observed and the prescriber was notified. It should be noted that 52 of the 302 PharmInts (17.2%) had no response (validation or non-validation of notification) from the prescriber.

Discussion

Various studies have highlighted the risk of CPOE to produce errors that may be life-threatening for patients [2,14,15,16]. Thus, each healthcare center using a CPOE system must be aware of this situation [8,10,17,18,19,20]. Our study focused only on errors that were encountered when using CPOE to manage pediatric patients.

It should be noted that the lack of information regarding pediatric bodyweight was the most frequent error and was the main cause for a PharmInt in our study. Information on bodyweight is crucial for checking accurate drug dosages [15]. However, because bodyweight

information is not mandatory when completing prescriptions via the CPOE system, clinicians often prescribe despite the absence of a patient's weight. Pharmacists usually notify the absence of bodyweight data and will indicate this on the Pharma® database, as well as making phone contact to approve the prescription. Consequently, data on bodyweight may be included later, although this is not always the case. The process of supplementing data is time consuming and reduces the advantages of using CPOE. This problem could be resolved by the software designer who could make it mandatory to provide information on a patient's bodyweight before a prescription can be filled. Prescribers would then be aware of this absence before pharmacy approval and thus be able to eliminate this problem.

In our study, errors related to paracetamol prescriptions were recurrent as it is frequently prescribed to children. Although it might seem insignificant to prescribers, errors in administration frequency might be problematic as it can expose the patient to an overdose that can be highly toxic to pediatric patients [21,22]. Moreover, some drugs, such as paracetamol or phloroglucinol, are prescribed under the notice of “when needed”. In these conditions, when information about time intervals between doses is absent, errors may occur, such as administrating the total dose (per day) all at once, and thus exposing the patient to toxic levels [22]. Other errors, such as an incorrect drug name or dose are potentially dangerous to all patients, but particularly when they are pediatric patients [7,20].

As reported previously, these errors can occur when the prescriber chooses an incorrect drug from the list of drugs proposed by the CPOE software, which calls for prescribers, pharmacists, and nursing personnel to be more attentive [1,2,5,19]. In our study, clinical pharmacists detected and informed the prescriber of errors using Pharma® *via* PharmInt which was either validated or not by the prescriber. However, as previously noted, many PharmInts that had an error were left without a response from the prescriber. Thus, pharmacists frequently need to phone or make personal contact with the prescriber before

validation of a questionable prescription. This reduces the benefits of the CPOE, which is to enable more rapid and efficient communication between health-care actors and is fundamental in optimizing healthcare management [1,5,21].

Modification of the prescription unit has also been reported to be one of the CPOE errors [10]. In our study, we noted 30 cases of inappropriate modification prescription unit which could lead to potential errors of administrations. For example, Dalteparine should be prescribed either 2500 UI anti-Xa/administration or 1 syringe/administration according to hospital recommendations. In Pharma®, “syringe” is the unit as the default of dalteparine. In two cases, “syringe” was modified by prescriber to “UI anti-Xa”, which led to a dose of 1 UI anti-Xa instead of 2500 UI anti-Xa.

Conclusion

We have researched the use of a CPOE in France, specifically with regards to pediatric patients as they are particularly vulnerable to medical errors.

Our work revealed several error types in prescribing for pediatric patients, mainly absence of bodyweight, incorrect frequency of administration and excessive doses. The role of better software design is pivotal to avoiding these errors. Consequently, we decided to make it mandatory to provide bodyweight data on the Pharma® form.

In addition to optimizing the quality of CPOE-entries, well-designed software, better-trained users, and improved communication among healthcare will reduce errors.

Clinician pharmacists should have a key role in education prescribers to respect the required parameters and to elaborate computerized pediatric protocols.

Finally, communication between healthcare actors can be improved by using CPOE system tools, such as comments, and notes. These interventions can be rapidly shared when using

this computerized method, and allowed to secure the ordering system and to improve the quality of healthcare management.

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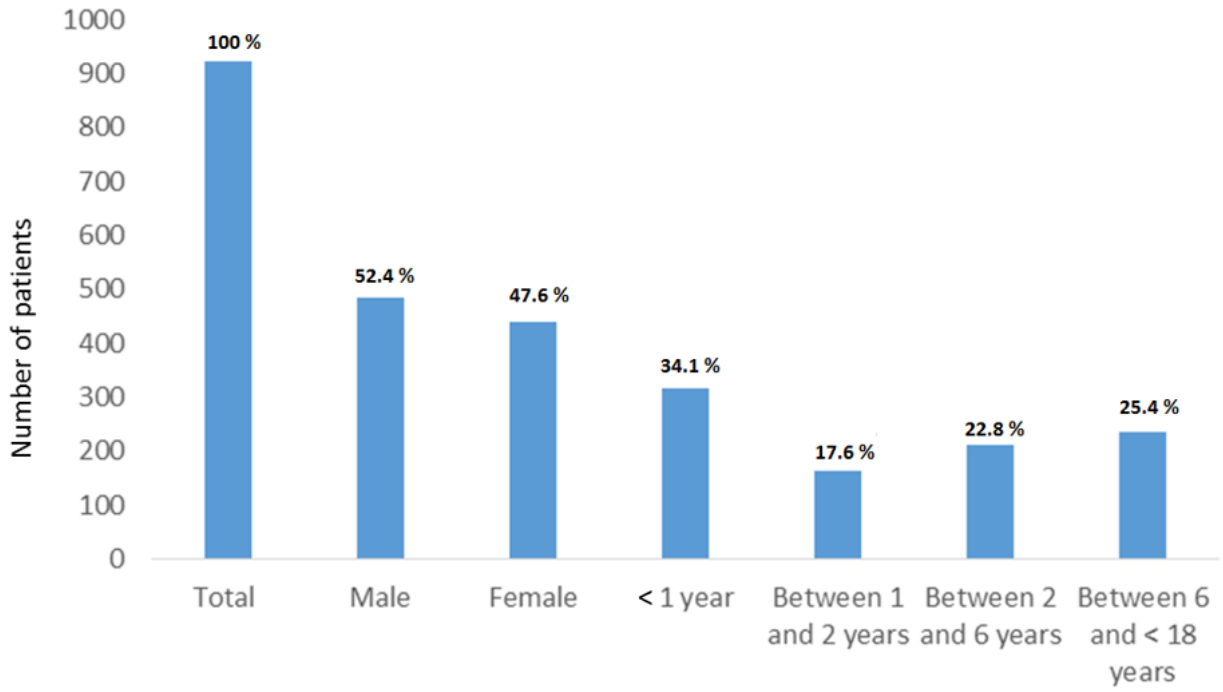

Figure 1: Characteristics of patients admitted into the pediatric department and registered into Pharma® during the study period.

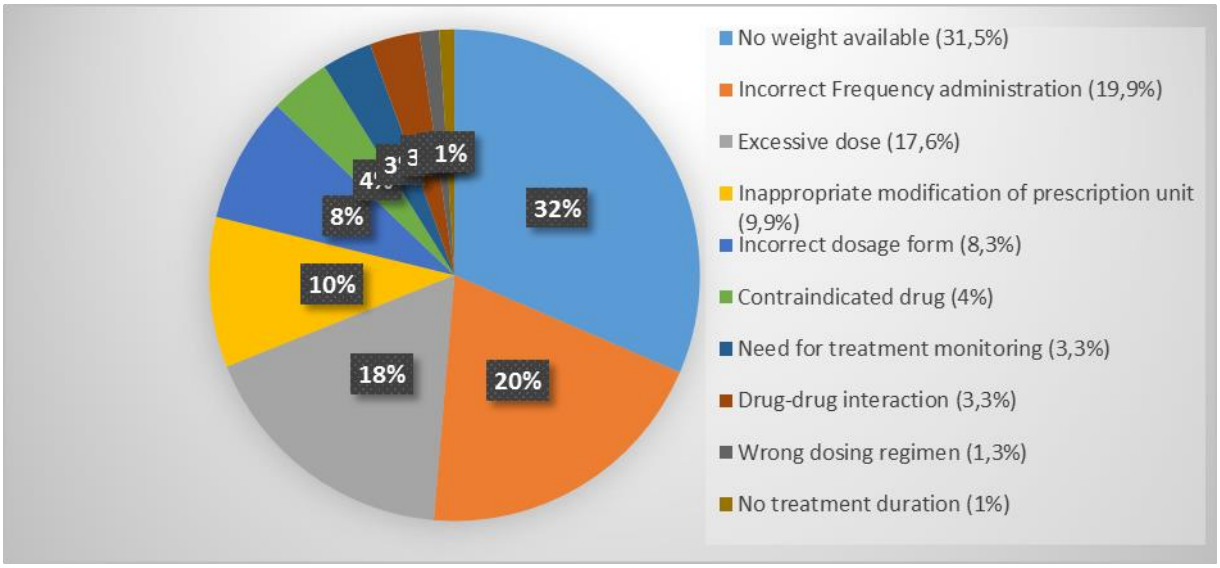

Figure 2: Frequency of pharmacist interventions regarding errors encountered on the computerized prescriptions.

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Table 1: Total pharmacist interventions regarding errors encountered on the computerized prescriptions.

Subject of PharmInt	**Frequency of PharmInts (%)**
Incorrect Frequency administration	60 (19.9)
Excessive dose	53 (17.6)
a	47 (15.6)
No weight available	
b	48 (15.9)
No weight available	
Inappropriate modification of prescription unit	30 (9.9)
Incorrect dosage form	25 (8.3)
Prescription of a contraindicated drug	12 (4.0)
Need for treatment monitoring	10 (3.3)
Presence of drug-drug interaction	10 (3.3)
Wrong dosing regimen	4 (1.3)
Absence of treatment duration	3 (1.0)
Total	302 (100)

PharmInt : Pharmacist intervention

a: Bodyweight was supplied to Pharma® due to the PharmInt, b: bodyweight was never supplied to Pharma®, despite the PharmInt

Table 2: Pharmacist interventions and errors encountered with the prescribed drugs.

INN (commercial name)	Errors	Number of PharmInt (%)
Paracetamol in different forms	Incorrect dosage form, co-administration of two paracetamol-containing drugs, inappropriate modification of prescription unit, incorrect frequency administration, no bodyweight available	91 (35.7)
Esomeprazole 10 mg sachet (Inexium)	Inappropriate modification of prescription unit	19 (7.5)
Phloroglucinol 80 mg lyoc (Spasfon)	Inappropriate modification of prescription unit incorrect frequency administration	29 (11.0)
Amikacine 50 mg injectable	Excessive dose	15 (5.9)
Ceftriaxone 500 mg for intravenous injection (Rocephine)	Re-evaluation not indicated	15 (5.9)
Ketoprofen 100 mg tablet, (Profenid), 100 mg LP (Bi-profenid) and 100 mg/ 2ml injectable (Profenid)	Incorrect dosage form, contraindicated and co-administrated with anticoagulants	5 (2.0)
Cefotaxime 1g injectable (Claforan)	Re-evaluation not indicated	4 (1.6)
Clonazepam 1 mg injectable (Rivotril)	Excessive dose	4 (1.6)
Hydroxyzine syrup 200 mL (Atarax)	No information about bodyweight	4 (1.6)
Ondansetron 2 mg/mL solution injectable (Zophren)	Wrong dosing regimen	4 (1.6)
Oxytetracycline 1.335 mg + dexamethasone 0.267 mg ophthalmic ointment (Sterdex)	Contraindicated	4 (1.6)
Salbutamol 100 mcg/dose (Ventoline)	Excessive dose	4 (1.6)
Association two drugs containing amoxicilline (Clamoxyl and Augmentin)	Utility of such association	3 (1.2)
Cefixime 40 mg or 100 mg /5 mL oral suspension	Inappropriate modification of prescription unit	3 (1.2)
Miconazole 2% gel buccal (Daktarin)	Contraindication	3 (1.2)
Pantoprazole 20 mg tablet (Eupantol)	Incorrect dosage form	3 (1.2)
Amoxicilline 1g and clavulanic acid 200 mg, tablet (Augmentin)	Absence of treatment duration, inappropriate modification of prescription unit	2 (0.8)
Amphotericin B 10% oral suspension 40 mL (Fungizone)	Inappropriate modification of prescription unit	2 (0.8)
Dalteparine 5000 UI AXa/0.2 mL injectable solution	Inappropriate modification of prescription unit, co-administration of NSAI drugs	2 (0.8)
Dimeticone 2,25 g gel oral tube (Polysilane UPSA)	Excessive dose	2 (0.8)
Fluticasone 125 mcg/dose (Flixotide)	Excessive dose	2 (0.8)
Ibuprofene 400 tablet (Spifen), 20 mg/mL (NurofenPro)	Co-administration with anticoagulant drugs, inappropriate modification of prescription unit	2 (0.8)

Morphine 10 mg/ 5mL	Excessive dose	2 (0.8)
Phloroglucinol 40 mg/4 mL injectable (Spasfon)	Incorrect dosage form, inappropriate modification of prescription unit, incorrect frequency administration	2 (0.8)
Saccharomyces boulardii 200 mg capsules (Ultralevure)	Contraindicated	2 (0.8)
Sulfamethoxazole 200 mg/5 ml + trimethoprime 40 mg/5 ml suspension (Bactrim)	Inappropriate modification of prescription unit	2 (0.8)
Tramadol 100 mg/2mL injectable (Topalgic)	Co-administration of morphine, excessive dose	2 (0.8)
Tramadol 50 mg LP capsule (Topalgic)	Excessive dose	2 (0.8)
Trimebutine 100 mg tablets (Debridat)	Excessive dose	2 (0.8)
Aciclovir 500 mg solution for perfusion (Zovirax)	Excessive dose	1 (0.4)
Amoxicilline 250 mg/5ml suspension (Clamoxyl)	Absence of treatment duration, inappropriate modification of prescription unit	1 (0.4)
Azithromycine 40 mg/mL oral suspension (Zithromax)	Initial treatment duration exceeding 3 days	1 (0.4)
Betamethasone 0.05% oral solution (Celestene)	No information about bodyweight	1 (0.4)
Chlorhexidine 0.5 ml/100 mL + chlorobutanol 0.5 g/100 mL solution mouthwash (Eludril)	Incorrect dosage form (alcohol containing form)	1 (0.4)
Ciprofloxacine 500 mg/5mL oral suspension (Ciflox)	Inappropriate modification of prescription unit	1 (0.4)
Diclofenac sodique 25 mg suppository (Voltarene)	No weight available	1 (0.4)
Diosmectite 3 g (Smecta)	Excessive dose	1 (0.4)
Dorzolamide 20 mg/mL + timolol 5 mg/ml collyre (Cosopt)	Not used for pediatric patients	1 (0.4)
Enoxaparine 2000 UI AXa/0.2 ML (Lovenox)	Treatment monitoring	1 (0.4)
Fluticasone 250 mcg/dose + salmeterol 25 mcg/dose (Seretide)	Excessive dose	1 (0.4)
Glycerine suppository	Excessive dose	1 (0.4)
Ivermectine 3 mg tablets (Stromectol)	No information about bodyweight	1 (0.4)
Methylprednisolone 120 MG INJ	Incorrect dosage form	1 (0.4)
Montelukast 5 mg tablets (Singulair)	Incorrect dosage form	1 (0.4)
Naproxene 250 mg tablets (Naprosyne)	Incorrect dosage form, excessive dose	1 (0.4)
Omeprazole 10 mg tablets (Mopral)	Incorrect dosage form	1 (0.4)
Trimébutine 50 mg/5 mL injectable solution (Debridat)	Contraindicated	1 (0.4)
Tobramycine 0.3 % eye drops (Tobrex)	Excessive dose	1 (0.4)

Total PharmInts	255 (100)

INN: International non-proprietary name, PharmInt: pharmacist intervention