

Implementation of a Computerized Provider Order Entry System in a Pediatric Hospital in Canada

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Abstract. The Centre Hospitalier Universitaire Sainte-Justine (Montreal, Canada) is a pediatric academic tertiary hospital that has begun the implementation of a commercial computerized provider order entry system (CPOE) in October 2019. The objectives of this paper are 1) to estimate the impact of the CPOE system on medication errors, and 2) to identify vulnerability issues related to the configuration of the CPOE system's design. Using a pre-post implementation methodology measuring medication errors captured by clinical pharmacists revealed that the implementation of a CPOE has eliminated all prescription conformity (e.g., missing fields) and legibility errors. Pharmacists have continued to detect medication errors, especially inappropriate dosing instructions, and to intervene in similar clinical situations (medication reconciliation, deprescribing, adjusting orders). Additionally, the vulnerability analysis, based on typical clinical order test cases in an inpatient pediatric setting, highlighted the need to configure a clinical decision support system that can identify inappropriate dosing instructions for pediatric patients.

Keywords. Computerized provider order entry, CPOE, electronic prescription, medication error, usability evaluation

1. Introduction

Computerized provider order entry (CPOE) has been pushed forward as a priority in the last decade to achieve digital excellence and improve the quality and safety of prescribed medications [1]. Although electronic health records (EHRs) and CPOEs have been implemented for more than two decades in many healthcare institutions around the world, the Centre hospitalier universitaire (CHU) Sainte-Justine is currently one of the first healthcare institutions in the province of Quebec to have implemented a CPOE system enabling the electronic prescription and transmission of provider orders (e.g., medication, lab, imaging, nursing orders, etc.). This study seeks to describe the implementation

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process of a commercial CPOE system and its impact on medication problems, which is known to depend greatly on the healthcare setting and on the CPOE system configuration [2]. Furthermore, we will present the results of a formative usability testing, in which we conducted a vulnerability analysis of the CPOE system prior to its implementation.

2. Methods

2.1. Setting and Implementation

The study was performed in a 60-bed general pediatric medicine unit, which served as the pilot unit for the implementation of the CPOE system at the 300-bed mother and child center. Clinical pharmacists are present both on the pediatric unit (participating in hospital rounds, reviewing medication regimens and clinical notes) and at the hospital pharmacy (validating and dispensing orders). Prior to the implementation of the CPOE system, all orders were written in manuscript on paper medical records and scanned to the pharmacy department. The CPOE application (GESPHARxLite), which was fully deployed in the pediatric unit in October 2019, was co-developed by CGSI@SOLUTIONS-TI (Quebec, Canada) and the CHU Sainte-Justine. Additionally, a work group comprised of providers in the pediatric unit was created to ensure that the order sets were adapted to the hospital workflow and processes. GESPHARxLite also has an electronic medication administration record (eMAR) module and is interfaced with the hospital's pharmacy information system (GESPHARx8). It also integrates a clinical decision support system (RxVigilance by Vigilance Santé), which is deactivated by default, and can be activated based on the provider's preference. During pilot testing, additional computer carts, card readers, and training rooms were set up to ensure that providers would be prepared for the implementation. Training was required for all providers (physicians, nurses, pharmacists, nutritionists, etc.), with modules to be completed online, followed by order scenario testing in classroom. Full time on-floor technical support was available during the fourth months following the implementation.

2.2. Pre-post Study on Medication Orders Problems

Prescription problems, identified through 1) interventions reported daily from the clinical pharmacists and 2) manual review of the pharmaceutical records, were collected for one workweek before CPOE implementation (August 26th – 30th, 2019) and one year later (August 31st – September 4th, 2020). Medication orders were analyzed according to patient characteristics (age, weight, number of medication orders), prescriber characteristics (type of healthcare provider, years of experience, specialty) and prescription details (drug class, administration route). The study was approved by the ethics committee of the CHU Sainte-Justine, Montréal, Canada.

2.3. Vulnerability Analysis

To identify usability problems related to a CPOE medication system, three experts (2 pharmacists, 1 human factor engineer) completed a walkthrough of an ordering task based on standardized order scenarios. The 19 test scenarios, inspired by those in Schiff et al's work around vulnerability testing of CPOE systems, were adapted for the local

pediatric context by clinical pharmacists from the hospital and are described in Figure 1 [3]. Fifteen out of these test cases (TC) were erroneous, non-optimal or potentially unsafe orders (test cases 1 to 15), while the remaining were complex orders with a risk of generating an incorrect order (test cases 16 to 19). Experts were asked to enter these problematic orders to evaluate the degree of difficulty associated with entering these orders (where 1 was easy; 2 required minor workarounds; 3 presented some protections; 4 was difficult and 5 was impossible). Although previous literature has aimed for a score of 5 for an ideal CPOE, the expected score of difficulty for these scenarios has been adjusted based on the clinical situation (by justifying potential cross allergies or drug interactions; e.g., TCs 11, 12, 13).

3. Results

3.1. Prescription Quality

A total of 375 and 521 medication orders were collected in August 2019 and August 2020 respectively. The most commonly prescribed medications were acetaminophen (10 vs 16%), other analgesics (NSAIDs and opioids) (6 vs 7%), antibiotics for systemic use (11 vs 20%), corticosteroids for systemic use (8 vs 4%), and vitamins and minerals (14 vs 6%). Table 1 summarizes the type of pharmacy interventions and prescription errors

Table 1. Summary of the type of medication orders problems before and after CPOE implementation (data collected for one workweek each)

Type of medication orders problems	Manuscript orders		Electronic orders	
	N	% (95% CI)	N	% (95% CI)
All orders	375	100	521	100
1. Prescription conformity *§	15	4.0 (2.0-6.0)	0	0
2. Inappropriate order	8	2.1 (0.7-3.6)	12	2.3 (1.0-3.6)
2.1 Subtherapeutic dose	1	0.3 (0.0-0.8)	1	0.2 (0.0-0.6)
2.2 Supratherapeutic dose	1	0.3 (0.0-0.8)	3	0.6 (0.0-1.2)
2.3 Inappropriate pharmaceutical form	2	0.5 (0.0-1.3)	8	1.5 (0.5-2.6)
2.4 Inappropriate dosing interval	4	1.1 (0.0-2.1)	0	0
2.5 Other (duplication, allergies, interaction, contraindication)	0	0	0	0
3. Clinical pharmacist's interventions	22	5.9 (3.5-8.3)	16	3.1 (1.6-4.6)
3.1 Medication not required (deprescribing)	9	2.4 (0.9-4.0)	7	1.3 (0.4-2.3)
3.2 Suggesting a medication	6	1.6 (0.3-2.9)	1	0.2 (0.0-0.6)
3.3 Ordering a medication taken at home	4	1.1 (0.0-2.1)	7	1.3 (0.4-2.3)
3.4 Dose adjusted based on clinical situation (e.g., monitoring based on serum level)	3	0.8 (0.0-1.7)	1	0.2 (0.0-0.6)
4. Other order issues	14	3.7 (1.8-5.6)	3	0.6 (0.0-1.2)
4.1 Unreadable prescription	1	0.2 (0.0-0.8)	0	0
4.2 Drug not prescribed properly in CPOE	0	0	3	0.6 (0.0-1.2)
4.3 Missing medication at the pharmacy	3	0.8 (0.0-1.7)	0	0
4.4 Drug not in the hospital formulary	5	1.3 (0.2-2.5)	0	0
4.5 Other †	5	1.3 (0.2-2.5)	0	0

* According to the CHU Sainte-Justine medication order conformity criteria listed in Ballandras et al. [4]

§ Issues with prescription conformity were as follow: Missing weight 1; missing date 1; missing dosing interval 3; missing dose 6; missing route of administration 4.

† Including scanning issues, unclear prescription, pharmacy technician did not enter order, wrong patient file, treatment duration missing

before and after CPOE implementation. There were no issues with prescription conformity and legibility in the post-implementation period, as expected with the implementation of a CPOE with required fields. Although the CPOE has eliminated illegible orders from manuscript orders, pharmacists have reported correcting orders in the CPOE because the initial orders were not entered properly (e.g., complex orders that required particular instructions, provider selected wrong pharmaceutical form). In addition to identifying inappropriate orders, pharmacists also played a major role in adjusting orders based on patients' clinical situation, both before and after CPOE implementation (problem 3).

3.2. Vulnerability Analysis

Figure 1 illustrates the average score of ease of entry for each test case attributed by the three experts. The CPOE system was particularly strong at detecting duplicate medication orders (TC1), drug-drug interactions (TC13), and some allergies (TC11). If the provider chooses explicitly to enter an allergy to a specific drug instead of a drug class, the clinical decision support (CDS) system does not create an alert on the risk of cross-allergy (TC12). The risk of entering a wrong drug due to the system's autocompletion feature, which has been identified as one of the most important health technology risks for 2021 [5], was not present when tested in TC16 and did not lead to any errors during our post-implementation observation week. Seven out of the 15 problematic test orders were scored as an easy order, and had no workarounds or protections preventing the provider from prescribing orders with the wrong dosing instructions. The identification of these wrong dosing instructions would require more advanced CDS features adapted to the inpatient pediatric population, where there is a high variability between the appropriate dosages, notably because many dosages are

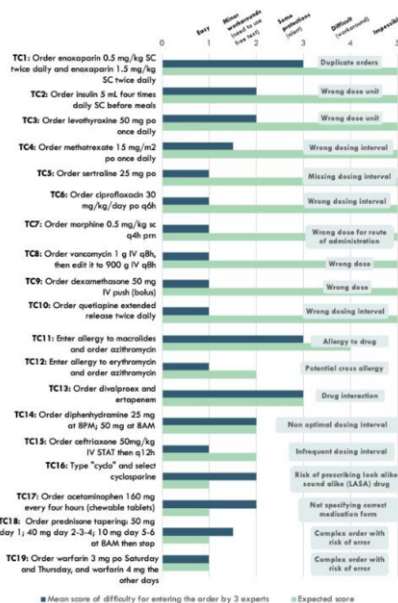


Figure 1. Mean score attributed by 3 expert users for each of the 19 test cases (TC), compared to the expected score. A score of 1 is associated with an order being easy to complete without workarounds or protections, whereas a score of 5 is considered to be an order that is impossible to be completed

weight-based. As showcased in Table 1, the issues with inappropriate dosing instructions have remained after CPOE implementation.

4. Discussion and Conclusion

To the best of our knowledge, this paper is the first study in the province of Quebec that evaluates the impact of a local, commercial CPOE system. This study aligns with results from previous studies, that have also identified a significant decrease in conformity errors [6]. Given the unique context of the implementation of this technology in a French-speaking hospital dedicated to pediatrics and obstetrics and the wide variations in system configurations on the market, we developed indicators adapted to local context, as well as the pediatric setting, to evaluate the quality of these orders. Considering that the CHU Sainte-Justine has been an early CPOE adopter in the province, this study will enable other institutions in the province to assess the implementation of a CPOE system. Additionally, this pre-post study aims to contribute to the lack of data regarding medication errors among pediatric inpatients. Indeed, although Gates et al.'s meta-analysis revealed that hospitals with CPOEs reported a lower rate of pediatric dose errors than those with paper charts, it noted that there are currently too few pre-post studies to allow for a pooled estimate of the impact CPOEs of pediatric order errors [7]. A limitation associated to this study include the manual review of scanned manuscript prescriptions, which has limited our ability to collect a larger set of order data in the pre-implementation phase. An ongoing analysis will assess individual accident and incident reports related to medication reports to better understand the contextual elements that might have contributed to medication errors since the implementation of the CPOE system. Future research will evaluate the impact of the CPOE system in other units at the hospital and focus on the use of validated tools to evaluate medication-safety related decision support integrated within the CPOE, such as the Leapfrog tool [8].

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