Improving Medication Safety in a Pediatric Hospital: A Mixed-Methods Evaluation of a Computerized Provider Order Entry – Supplemental Material

Supplementary Material – Table 1. Components and characteristics of the CPOE system

SAFER Guide Recommended Practices	Comments and examples
Fully Implemented 1. Coded allergen and reaction information (or "no known allergies" [NKA]) are entered and updated in the EHR prior to any order entry (Practice 1.1). 2. Evidence-based order sets are available in the EHR for common tasks and conditions and are updated regularly (Practice 1.2) 3. User-entered orderable items are matched to, or can be looked up from, a list of standard terms (Practice 1.3). 4. The EHR can facilitate both cancellation and acknowledgment of receipt of orders for laboratory, radiology, and pharmacy (Practice 1.4). 5. Clinicians are trained and tested on CPOE operations before being issued login credentials (Practice 2.1). 6. CPOE is used for ordering all medications, diagnostic tests, and procedures for which CPOE is available (Practice 2.3). 7. There is minimal use of free-text order entry. Orders are entered and stored in standardized, coded form (Practice 2.4). 8. Drug-allergy interaction checking occurs during the entry of new medication orders and new allergies (Practice 2.7). 9. Clinicians are required to re-enter their password, or a unique PIN, to “sign” (authenticate) an order (Practice 2.13). 10. CPOE and CDS functionality are tested to ensure proper operation before go-live and with test patients in the production system before clinical use (Practice 2.16). 11. Questions presented to the user by CPOE or CDS are unambiguous (Practice 2.17). 12. CPOE and CDS implementation and use are supported by usability testing based on best practices from human factors engineering (Practice 2.18). 13. Critical patient information is visible during the order entry process (Practice 2.19). 14. Use of abbreviations and acronyms is minimized and standardized (Practice 2.21).	N/A
Partially Implemented 1. CDS alerts are displayed in the relevant clinical context (Practice 1.5). 2. Clinicians are engaged in implementing, reviewing, and updating CDS (Practice 2.2). 3. Order entry information is electronically communicated (e.g., through the computer or mobile messaging) to the people responsible for carrying out the order (Practice 2.5). 4. Interruptive alerts (e.g., pop-ups at the time of ordering) are used with discretion and only for high risk, high priority conditions (Practice 2.6).	1. Allergy and duplicate order alerts are displayed during the prescribing process. However, more advanced alerts are displayed at the end of the prescribing process. 2. Interruptive alerts are displayed in case of allergies.

5. Duplicate order checking occurs for high risk medication, diagnostic tests, and procedure orders (excluding "as needed" [PRN] medications) (Practice 2.8). 6. Drug-condition checking occurs for important interactions between drugs and selected conditions (Practice 2.9). 7. When appropriate, corollary (or consequent) orders are automatically suggested and linked together with the original order such that changes are reflected when the original order is rescheduled, renewed, or discontinued (Practice 2.14). 8. The clinician is informed during the ordering process when additional steps are needed to complete the order being requested (Practice 2.20). 9. Additional safeguards are implemented in the EHR before high-risk medications are prescribed (Practice 2.22). 10. Key metrics related to CPOE and CDS (e.g., override rates) are defined, monitored, and acted on to optimize safety and use (Practice 3.1).	3. The CDS displays duplicate orders alert, but is not yet well coordinated to eliminate these alerts when not necessary. 4. There is a drug-condition checking for patients with a ketogenic diet. 5. Corollary orders are linked together for orders prescribed using pre-filled forms 6. Additional steps for clinicians are in an orange bold font. 7. A link describing high-risk medication appears when clinicians are ordering high - risk medications. 8. Key metrics are monitored in an informal way.
Not implemented 1. CDS incorporates current best practices and guidelines from authoritative sources (e.g., national organizations, medical specialty professional associations) (Practice 1.6). 2. Drug-patient age checking occurs for important age- related medication issues (Practice 2.10). 3. Dose range checking (e.g., maximum single dose or daily dose) occurs before medication orders are submitted for dispensing (Practice 2.11). 4. A process is in place to review interactions so that only the most significant interaction-related alerts, as determined by the organization, are presented to clinicians (Practice 2.12). 5. Users can access authoritative clinical reference materials directly from the EHR, including organization-specific information when available (Practice 2.15).	1. No pediatric specific drug-drug interaction alerts

Supplementary Material – Table 2. Comparison of the Medication Management Process Before and After the Implementation of the CPOE System in the Pediatric Unit at the CHU Sainte-Justine

	Pre-CPOE implementation	**Post-CPOE implementation**
Ordering	• Weight and allergy information required for each prescription paper • Manuscript orders for all orders • Use of pre-filled paper formularies for certain conditions when applicable	• Weight and allergy information entered in the CPOE when admitting the patient to the unit • Computerized order entry system for all orders • Use of electronic pre-filled forms and order sets when applicable • Option to activate clinical decision support system (CDSS) (RxVigilance)
	• Paper medication reconciliation and discharge orders • Manuscript orders coming from other units • Rounding pharmacists covering all 60 beds in the pediatric unit • Attending physicians from the pediatric unit needs to countersign orders from external consultants and other providers.	
Acknowledgment*, transmission, and transcribing	• Patient files with new orders are flagged with a color code. • Nurses scan prescriptions to the pharmacy. • Nurses transcribe the order in the electronic medication administration record using pre-defined lists. • Pharmacy technicians transcribe the entire order manually.	• Dashboard monitor at nursing stations used to alert new prescriptions. • Electronic transmission to the pharmacy. • Electronic medical administration record is auto-populated with information from the order and updated with pharmacy order information once validated. • Pharmacy technicians import order data from CPOE and complete the remaining order information.
Pharmacy validation and dispensing	• Pharmacists use a pharmacy information system (PIS) (GESPHARx8) to verify and dispense medication orders. • Fluids and electrolytes orders are not transmitted to the pharmacy department (unless non standard order requiring pharmacy verification or dispensing) • On-unit automated medication dispensing cabinets	
Nurse administering	• Since 2017, nurses use an electronic medication administration record (eMAR) to document medication administration and double checking when applicable. • Nurses use Kardex to record electrolytes and fluids administration. • No bar-code medication administration (BCMA) • No integration between the eMAR and infusion devices	

* Nursing order acknowledgment refers to the process of reading the order, ensuring that the order is entered in the eMAR, and carrying out the required tasks associated with the order (e.g., transmitting the order to the pharmacy, laboratory, or radiology department, providing nursing care).

Supplementary Material – Table 3. Type of Medication Errors and Potential Prevention Strategies Before and After the Implementation of the CPOE System

Variable	Pre-CPOE implementation		Post-CPOE implementation	
	N = 133	100 %	N = 109	100%
Drug category				
Anti-infective drugs	43	32	30	28
Analgesics and sedatives	17	13	13	12
Insulin	7	5	8	7
Systemic corticosteroids	7	5	3	3
Bronchodilators	6	5	6	6
Other	50	38	45	41
Missing information	3	2	4	4
Drug route				
Oral	61	46	39	36
Intravenous	50	38	45	41
Subcutaneous	9	7	7	6
Inhalation	6	5	6	6
Topical	2	2	2	2
Other	3	2	7	6
Missing information	2	2	3	3
Time of incident/accident				
Day	48	36	34	31
Evening	48	36	43	39
Night	37	28	32	29
Severity**				
A - Circumstance at risk of having consequences for the user (hazard).*	7	5	0	0
B - An event has occurred, but the user has not been affected (near miss).	11	8	5	5
C - An adverse event has occurred, affecting the user, without causing any consequences.	96	72	80	73
D - An adverse event occurred, affecting the user and additional verifications had to be made to verify the presence or appearance of consequences.	17	13	22	20
E1 - An adverse event has occurred, has affected the user, and has caused minor and temporary consequences requiring only non-specialized interventions.	2	2	2	2
Reporter				
Nursing				
Registered nurse	102	77	77	71
Nursing student	12	9	8	7
Nurse manager	11	8	14	13
Nursing teacher	2	2	0	0
Nurse practitioner	0	0	2	2
Physician				
Attending	2	2	2	2
Resident	0	0	2	2
Respiratory therapist	3	2	3	3
Pharmacist	0	0	1	1
Radiology technician	1	1	0	0

* Chi-squared difference in proportions [95% confidence interval] not significant, except for reports with a severity of level A: 5.3 % [0.6; 9.9]
** No reported events of severity E2 or higher.