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Evaluating the medication process in the context of CPOE use: The significance of working around the system

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ABSTRACT

Objective: To evaluate the problems experienced after implementing a computerized physician order entry (CPOE) system, their possible root causes, and the responses of providers in order to incorporate the system into daily workflow.
Methods: A qualitative study in the medication-use process after implementation of a CPOE system in an academic hospital in The Netherlands. Data included 21 interviews with clinical end-users, paper-based and system-generated documents used daily in the process, and educational materials used to train users.
Findings: The problems in the medication-use process included cognitive overload on physicians and nurses, unmet information needs, miscommunication of orders and ideas, problematic coordination of interrelated tasks between co-working professionals, a potentially faulty administration phase, and suboptimal monitoring of the medication plans. These problems were mainly rooted in the lack of mobile computer devices, the uneasy integration of coexisting electronic and paper-based systems, suboptimal usability of the system, and certain organizational factors with regard to procuring drugs affecting the technology use. Various types of workarounds were used to address the difficulties, including phone calls, taking multiple paper notes, issuing paper-based and verbal orders, double-checking, using other patients' procured drugs or another department's drug supply, and modifying and annotating the printed orders.
Conclusion: This study shows how providers are actively involved in working around the interruptions in workflow by bypassing the technology or adapting the work processes. Although certain workarounds help to maintain smooth workflow and/or to ensure patient safety, others may burden providers by necessitating extra time and effort and/or endangering patient safety. It is important that workarounds having a negative nature are recognized and discussed in order to find solutions to mitigate their effects.

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1. Introduction

The implementation of computerized physician order entry (CPOE) systems thoroughly transforms existing work practices [1]. This transformation benefits certain aspects of workflow such as better documentation of orders and shorter order turnaround times [2,3]. Nevertheless, it also challenges other workflow aspects such as collaboration between providers [4,5]. As a result, workflow issues have been found highly relevant not only for a successful implementation of CPOE systems but also for patient safety practices [6–8].

Studies of the actual use of health care information technology (HIT) in successful implementation sites have raised concerns about how and with what consequences these systems are operational in practice [7,9–11]. In an in depth qualitative study, Georgiou and colleagues showed how the use of a CPOE system can change the nature of clinical work [10]. They found that providers responded in different ways to the workflow issues faced after a CPOE implementation, ranging from soft responses and workarounds to hard responses such as new organizational rules [10]. Vogelsmeier and colleagues characterized two categories of workarounds in working with an electronic administration record: those related to workflow blocks introduced by technology and those related to organizational processes not reengineered to effectively integrate with the technology [11]. Koppel and colleagues showed that workarounds are the result of difficulties with the technology as well as of interactions between the technology and other factors such as "environmental, technical, work-processes, workload, training, and policies" [12]. It has been noted that workarounds developed in the use of CPOE systems may blur the workflow problems generated by these systems [7]. Such studies serve to focus attention on the organization of the work with CPOE systems and how it may be affected in a positive or a negative way. In other words, for a smooth as well as a safe workflow, it is highly relevant to evaluate and to understand how health care providers use, misuse, or bypass these systems in practice. However, despite the importance of the issue, only a few studies have attempted to characterize different responses of providers in the implementation environment and their consequences for clinical workflow.

Studies have pointed out the complexity of the medication-use cycle in hospitals, which highly influences CPOE use [13,14]. In our previous studies on the impact of a medication order entry system on inter-professional communication and workflow, we found that providers often took additional steps beyond the system to cope with disruptions [15,16]. Intrigued by this finding, in the present study we aimed to investigate how the parties involved in or affected by the implementation handled breakdowns in the medication-use process. These parties were physicians, nurses, the pharmacy department, and the implementation team, whom we will refer to hereafter collectively as "the work organization". Rather than merely focusing on the relationship between these responses and patient safety practices, which is *per se* of great importance, we attempted to extend the approach to explore their consequences for the structure of clinical workflow. More specifically, we were keen to evaluate and to understand the difficulties or breakdowns that take place in the medication-use process in the context of CPOE, their probable root causes, and the responses of the work organization to address them. This, we believe, can provide an insight into how these responses influence the providers' workflow as well as into which strategies can help to improve the situation.

2. Background

The implementation of an information technology such as a CPOE system is a process of mutual transformation in which the organization and the system transform each other [17]. Wynne referred to the "practical *contextualization* of technology" by users in which they develop informal operating rules by adapting general principles to specific circumstances in order to make the technology work in that situation [18]. This "*contextualization*" process may not follow the full scope of technology, so its driving local interests may be at cross-purposes with the overall technological system. In fact, it is largely the emerging practices resulting from the interaction between a technology, the implementation environment, and its users that determine its outcome rather than its rule-following specifications [18]. To address workflow issues and to ensure that the system operates in such an interaction process, the *sharp end-point users* and the context of the technology use play important roles [19].

"Workaround" is generally defined as a plan or method to circumvent a problem *without* eliminating it [20]. In a medical context, Kobayashi and colleagues have defined workarounds as "informal temporary practices for handling exceptions to normal workflow" [21]. In their view, workarounds represent alternative ways that providers devise to work around the breakdowns in normal workflow. Tucker and Edmondson called that "first order problem solving behavior", which "attempts to remedy the immediate problem but does not try to change underlying conditions that created it" [22]. A study of workarounds after the implementation of an electronic administration record suggests that providers devise workarounds as a means of "first order problem solving behavior" [11]. For the purpose of this study, we define workarounds as informal rules or work methods – not formally considered and outlined in the system design – employed in working with a system to handle a workflow problem [16].

Workarounds may prove to be successful in terms of dealing with *in situ* workflow blocks and then letting providers finish the daily course of tasks. For example, Koppel and colleagues in a CPOE context reported that because of cumbersome electronic medication charting providers recorded medications in parallel paper and electronic systems, which resulted in confusion and loss of medication data [7]. To access patient medication information, the providers then had to take additional, time consuming, and distracting steps such as inquiring directly from other providers. One study reported that providers used workarounds in response to both intentional technology blocks designed to enhance patient safety and unintentional technology blocks from ineffective technology design [11]. In this study, for instance, nursing home staff was required to document preparation of a medication first and then to document its actual administration to ensure

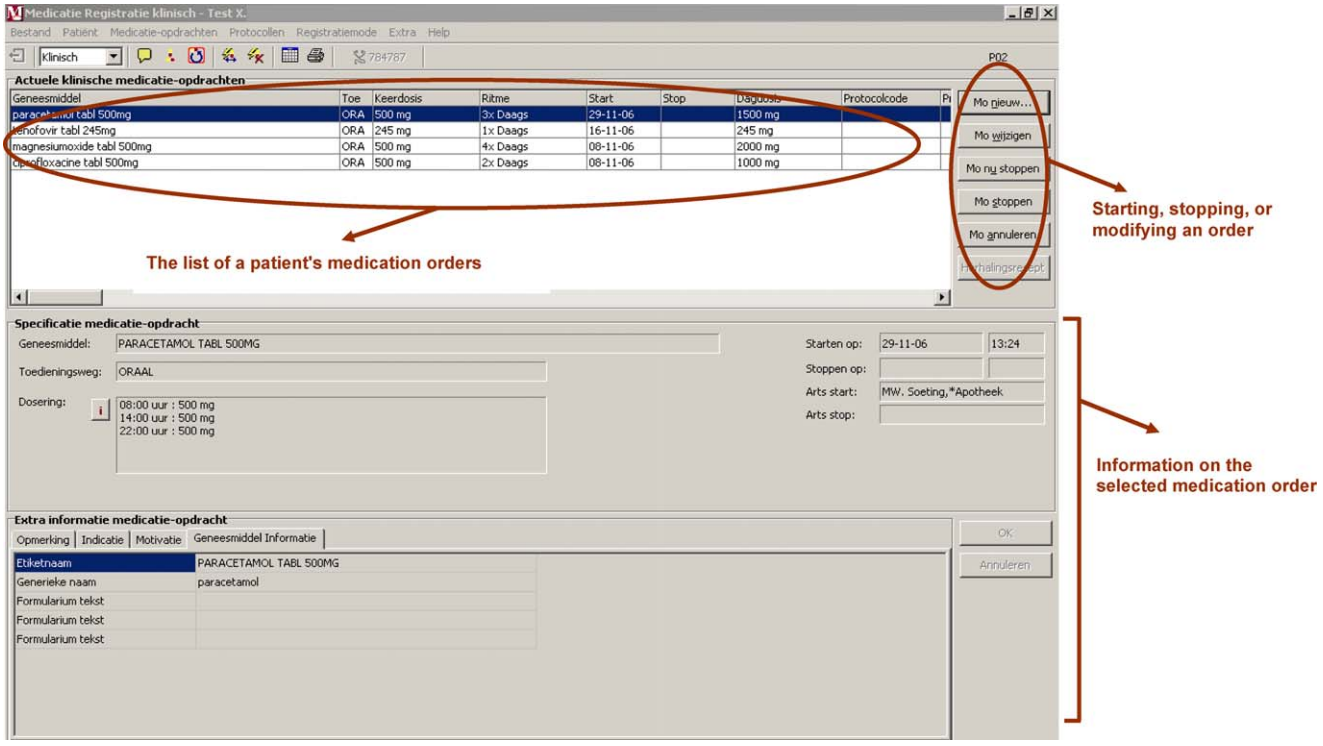

Fig. 1 – A screen shot of the CPOE system for physicians in a test patient.

patient safety. However, to bypass this dual administration documentation system, which was perceived cumbersome, the staff simply documented both preparation and administration *before* actually administering a medication. In a study of occurrences, causes, and threats of workarounds after barcode medication administration systems, such workarounds were categorized as "steps performed out of sequence" [12]. Two other categories of workarounds were also reported in this study: omission of process steps (e.g., physicians do not review electronic medication administration record to verify current medications) and unauthorized process steps (e.g., user takes the scanner separate from cart into the room where the cart alarm cannot be seen).

Moreover, workarounds developed in practice may even be used as organizational solutions for difficulties that recur after HIT implementations. For example, in the study of a pathology laboratory order entry system, it was reported that as soon as a clinician entered an order into the CPOE system, it generated an accession number assuming that the sample was drawn from a patient and sent to the laboratory or to be done soon [10]. In the cases the clinicians decided not to go ahead with these orders, their pending requests without the associated specimens were a source of frustration and confusion for laboratory staff. Because communication of the issue to the clinicians on the wards had no result, a new procedure was installed to check and cancel these orders after three days.

More importantly, although workarounds are widely used in practice, they might be unavailable, unstable, or unreliable [21]. Also, workarounds – especially unsuccessful ones – can unnecessarily increase the workload of providers as well as their cognitive efforts. A careful analysis of work processes to elucidate unsuccessful workarounds can therefore be one important step towards improving workflow and increasing the system adoption rate.

3. Methods

3.1. *Study site and the CPOE system*

We studied a vendor-based CPOE system, Medicatie/EVS® (version 2.30), iSOFT, The Netherlands (now iSoftHealth), at Erasmus University Medical Center, a 1237-bed academic hospital in Rotterdam, The Netherlands. A detailed description of an earlier version of Medicatie/EVS® has been published elsewhere [23]. The hospital began to implement the system in 2001. It took 5 years to implement the system hospital-wide in both inpatient and outpatient settings. The last inpatient unit started using the system in March 2005. The system has been integrated into other existing information systems in the hospital with the exception of the patient data management system (PDMS) used in intensive care units (ICUs).

Except in ICUs, almost all medication orders relating to hospitalized patients are entered by physicians using this CPOE system. The system can be accessed from all workstations throughout the hospital and in all physician offices. Because of budget constraints and information safety concerns (i.e., ensuring the information access only by authorized providers), laptops and wireless network were not in place at the time of this study (June 2007). A physician enters a medication order by selecting a drug and its dosage form, strength, administration route, dosage regimen, start date and time in

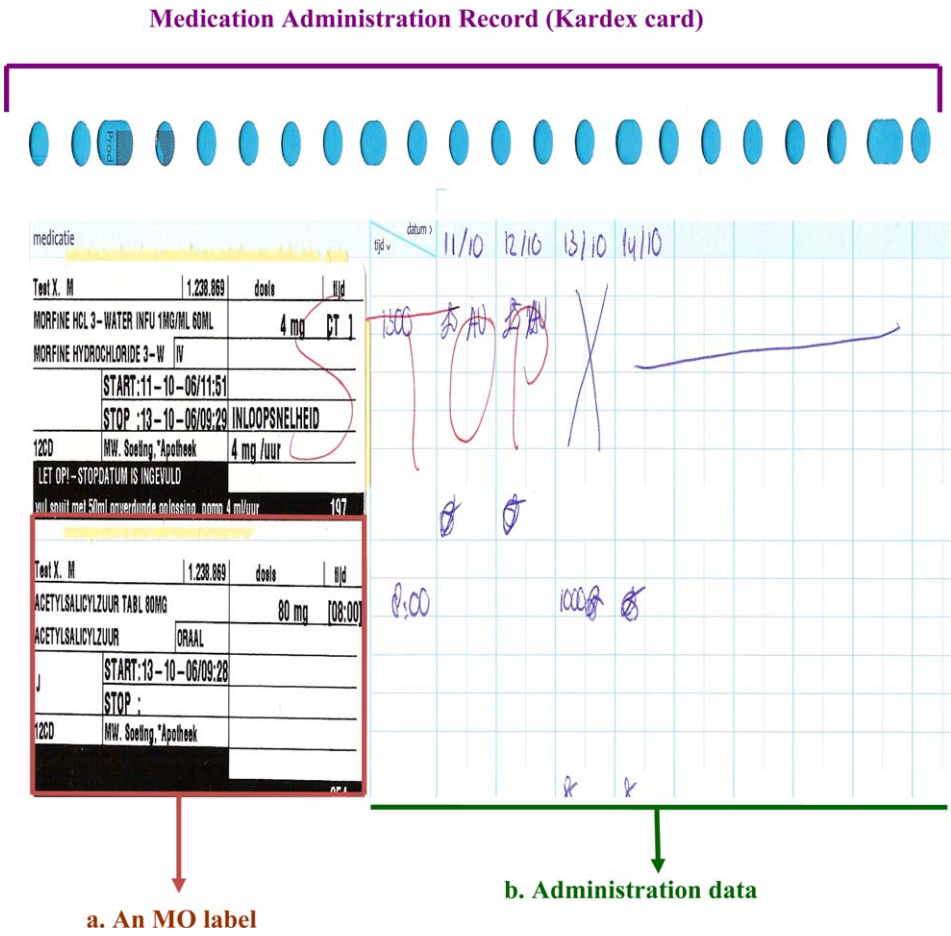

Fig. 2 – The paper-based medication administration record after the implementation of the CPOE system.

the system. Standard order sets and protocols can be selected as well. Fig. 1 shows a screen shot of the CPOE system for physicians.

The medication administration record (MAR) is still paper based (Fig. 2). After physicians enter a medication order electronically, nurses receive it on a 5.5 cm × 4.5 cm self-adhesive prescription label (an MO label) (Fig. 2a). These labels contain patient and medication information. Nurses affix these labels onto Kardex cards (Fig. 2). Next to the MO labels on the Kardex card, there are empty spaces where nurses sign when they give medication to the patient (Fig. 2b).

The system can also generate patients' current medication overview (AMO list), which contains a patient's latest medication orders and can be printed out. There are three different types of AMOs that are primarily used by nurses. Two AMOs provided by the software vendor present only one-day current medications. A third AMO gives a 10-day overview of all medications with start and stop dates. The later AMO was developed by the project team upon request of the physicians of the first ward that started using Medicatie/EVS®. Fig. 3 shows one type of AMO list. Nurses have been instructed with regard to the characteristics of each type of AMO during their training sessions and in their educational manuals. They print out one AMO per patient each 24 h.

3.2. *Data collection methods*

The focus of this study was on the five phases of the medication-use cycle: (1) prescribing, (2) communication of orders, (3) dispensing, (4) administration, and (5) monitoring (Fig. 4). Three main data sources were collected and used in this study: 1) transcripts of interviews with clinical end-users, (2) artifacts used in daily work, and (3) educational materials to train physicians and nurses to use the CPOE system.

In late 2006 and early 2007, the first two authors conducted 21 semi-structured interviews with clinicians involved in the medication-use cycle. The interviewees were among the key informant users who responded to our e-mail invitation or were recommended by the head of departments. Interviews lasted between 25 and 70 min (mean interview time 48 min). All interviews were conducted in the interviewee's work place, where they could show how they worked with the system in the medication process. All interviewees except one had the experience of working with the paper-based systems that preceded this electronic system. In adult inpatient settings, we interviewed 6 physicians and 12 nurses. They were recruited from key users of the system, representing nonsurgical (including general internal medicine, gastroenterology, nephrology, hematology, and pulmonology) and surgical spe-

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6501662
        091746  Start: 07-03-07/15:36    AMOXICILLINE TABL 750MG
                Stop :         /         AMOXICILLINE
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                                                                   22:00          750 mg
6403399
        091746  Start: 06-03-07/18:39    DEXAMETHASON CAPS 1MG
                Stop :         /         DEXAMETHASON
                                                    ORAAL          08:00            2 mg
                                                                   12:00            2 mg
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                                                                   22:00            2 mg
6701763
        091746  Start: 09-03-07/00:00    DEXAMETHASON CAPS 1MG
        091746  Stop : 09-03-07/23:59    DEXAMETHASON
                                         ;1e dag postoperatief
                                                    ORAAL          08:00            2 mg
                                                                   12:00            2 mg
                                                                   18:00            2 mg
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6801755
        091746  Start: 10-03-07/00:00    DEXAMETHASON CAPS 1MG
        091746  Stop : 10-03-07/23:59    DEXAMETHASON
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6901751
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        091746  Stop : 11-03-07/23:59    DEXAMETHASON
                                         ;3e dag postoperatief
                                                    ORAAL          08:00            1 mg
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Fig. 3 – One kind of AMO (a list of patient medication overview).

cialties (including general surgery, urology, and neurosurgery). In the pharmacy department, we interviewed two hospital pharmacists and a senior pharmacy technician. One of the pharmacists was the project manager of the implementation team, and she was involved in direct patient care after the implementation.

The interviews were audio-taped and transcribed verbatim. The interview topics covered the personal background, work experience with the CPOE system and its preceding paper-based system in this hospital, interviewees' roles and tasks in the medication process, their communication and coordination with other professionals, the use of the system and other patients' records for entering and retrieving the medication related information, and the benefits of the system in the medication process as well as the problems experienced in daily work. Depending on an interviewee's role, the questions were organized and directed to cover the five phases of the medication-use process mentioned above.

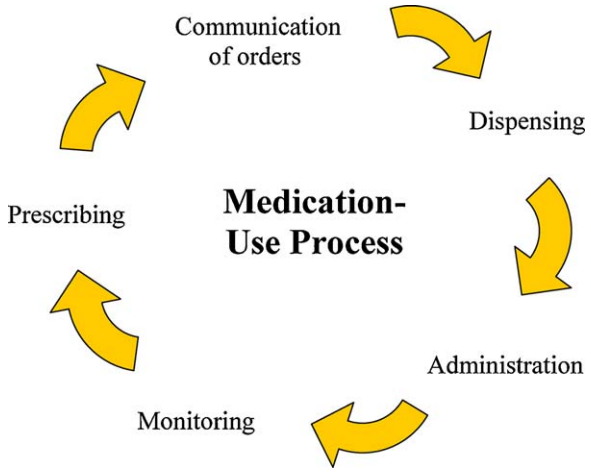

Fig. 4 – Five phases in the medication-use cycle.

Moreover, we also collected several paper-based documents and computerized printouts used in the medication process. These documents included: (1) printed orders (MO labels), (2) patient administration records (Kardex cards), (3) patients' current medication overview (AMO), and (4) appointment forms and "what to do lists". The "appointment form" is originally used to regulate nursing work such as laboratory and radiology requests.

3.3. *Analysis of data*

In this study, our aim was to examine the responses of the work organization to address difficulties in the post-CPOE medication-use process. The initial step in our analysis was process mapping of the post-CPOE medication process according to the five phases of the medication-use cycle (Fig. 4). Then, using an open coding technique, we derived two core

Table 1 – Problems encountered in clinical workflow, their probable root causes, and resulting workarounds.

Problems encountered	Probable root causes	Resulting workarounds
1. Prescribing		
• Information loss • Not having an overview of current patient medications	• Patient's clinical condition, order entry system, and medication administration record are not available at the time of decision-making or order entry phases	• When the patient is there for days, physicians rely merely on their memory • For new patients that they do not know: physicians check the information in their offices before doing rounds, make a patient summary, and take it with them to the bedside
• Order entry is in the physician's office away from the patient and co-working colleagues; • Lag between the order-entry time and that of decision-making when the memory is fresh	• Lack of bedside systems • Asynchronized decision-making and order entry	• Summarized paper-based notes of orders taken during medical rounds such as "patient number 3: change medication", "patient number 9: start new medication" and so forth; relying mostly on memory • Physicians write the orders in an appointment form and sign it • Nurses write orders in an appointment form and ask physicians to sign it during rounds
• Delay in entering the orders of newly admitted patients, especially when they are admitted after morning rounds or during evening shifts when physicians are busy	• Time-consuming process of order entry	• Verbal or paper-based orders for the most important and urgent medications • Calls from nurses to remind physicians to enter medication orders
2. Communication of orders		
• Communication of necessity for an urgent action: changes in orders such as stopping and starting medications that have been decided upon during morning rounds but have not yet been entered into the system (often happens daily)	• Lack of bedside systems and busy work schedules of physicians (especially residents) after morning rounds, keeping them from entering orders right away	• Physicians must emphasize the order verbally, then write it down and sign it for nurses (e.g., in nurses' notes, what to do list, appointment forms); • Or, nurses should directly inquire for confirmation once more after rounds by direct communication or a phone call
• Verbal communication of orders	• Busy evening or night shifts for residents • Emergency situations	• Nurses write down in the administration records or other nurses' notes that physician X prescribed medication Y on day Z • They also call physicians to follow up issuing the electronic versions of verbal orders
• Failed or delayed communicating of orders entered into the system	• Lack of proper order notification to nurses apart from the physical existence of MO labels, such as a highlighted new order in the system • Printer dysfunction or empty rolls of MO labels • MO labels may be lost among other papers in the nursing station • Other colleagues may pick them up by mistake	• Checking printers • Checking with physicians to ensure order entry by them • Physicians should call nurses or to tell them directly if they have entered a new order • Nurses may need to check the electronic orders, one by one for each patient, to see which orders are new, and then make their prints, which is a time-consuming process • In a few wards, the unit secretary is assigned to collect MO labels and distribute them to the nurses responsible

Table 1 – (*Continued*)

Problems encountered	Probable root causes	Resulting workarounds
• Discrepancy between the decisions made in the morning rounds and the orders entered into the system and received by the nurse • Ambiguity for nurses when they receive a medication order not discussed earlier • Miscommunication of ideas between physicians and nurses through the system	• Asynchronized decision-making and order entry phases when the physician's memory is fresh • Asynchronized decision-making and order entry phases, not at the same time that physicians are with nurses • Usability issues of the system (e.g., same-day start and stop dates)	• Nurses phone physicians for clarification: for example, if they receive something new or different from what that has already been discussed • Physicians need to call if they enter an order while away from the wards, especially in a case that needs special attention
• Nurses may not notice if there are medication orders requiring special attention especially if they are not emphasized earlier or are out of routine; or they may notice it only later	• MO labels are highly detailed and printed with black ink making all orders look alike • Lack of proper notification in instances when nurses must pay particular attention to the non-routine issue of a special medication	• Physicians should directly tell the responsible nurses or call to signal the need for special attention
3. Dispensing		
• High number of returned non-stock drugs from the wards to the pharmacy	• An automatic drug request was sent directly to the pharmacy following each non-stock order entry or its changes during a patient's hospital stay • Whole box delivery for each drug request	• Nurses were involved in selecting electronically those non-stock drug requests that were necessary in the wards • The pharmacy switched from checking the physician orders to checking the nurse requests
• Delayed nurse-initiated order request sent to the pharmacy	• Delay in receiving electronic medication orders in the course of the day due to the lack of bedside systems, on the one hand, and busy work schedules after morning rounds for residents, on the other hand • Nurses' drug requests would be canceled in the absence of electronic orders • Lack of proper notification of the latest requests through the system to the pharmacy technicians; time-consuming process of checking drug requests per patient per wards	• Calling back to physicians or directly communicating with them to remind them and to request an electronic order entry • Asking other physicians to order if the first physician is busy and cannot do so right away • Calling the pharmacy if an order request is placed in the computer after 12–2 p.m. • Checking the medications of other patients to see whether the same drug has already being requested and is now available in another patient's medicine box; nurses take it and write a note to refill it as soon as they receive the drug from the pharmacy • Asking patients to bring their home medications to the hospital, especially for the first few days
• Lack of in-stock drugs because of periodical variation in the flow of patients who use these drugs	• The pharmacy technicians would cancel a drug request if it is an in-stock drug	• Using the in-stock supply of other departments and writing down the names of the medications in order to return them after pharmacy technicians have come to scan and to re-stock supplies
• Dispensing of non-stock drugs that are expensive and need explanations for their prescription (e.g., penicillin group 4)	• Necessity of multiple communications for dispensing expensive drugs and lack of adequate coordination between pharmacists, physicians, and nurses about the final result	• Calls from pharmacy technicians to nurses to inquire about home medications (whether the patient has brought the drug in, how many days the patient will stay, etc.) • Calls from pharmacists to physicians to replace the drug with an alternative • Pharmacy technicians also use a local computer program to document the processes of inquiry from nurses and physicians and the name of patients and drugs. If they receive a similar request, technicians should first check this program before responding to an inquiry from nurses

Table 1 – (*Continued*)

Problems encountered	Probable root causes	Resulting workarounds
4. Administration		
• Drug administration without the electronic orders or their MO labels	• Verbal or paper-based orders during the medical rounds, due to lack of bedside systems • Busy physicians especially during evening and night shifts	• Nurses start administration of drugs based on physicians' verbal or paper-based orders, even if they do not have the electronic orders; meanwhile, nurses write the medication orders by hand either on Kardex cards where MO labels are affixed or in other nursing records • Nurses call back physicians to remind them to enter orders • The next shift nurse may ask other doctors to issue the electronic orders
• The nurse taking part in the morning round may not be the nurse who distributes the drugs during drug administration time	• Verbal orders for stop or start orders that have been decided upon in morning rounds	• Nurse one should communicate it verbally to nurse two • Nurse one may put an "S" mark on an AMO or on a Kardex card in front of the name of the medication that is to be stopped
• Incompatible drug administration times for some medications	• Structured order entry and centralized decision making by physicians • Usability issues when physicians use default times in the system	• Nurses cross out the items and add new ones that best match the temporal rhythms of nursing work and/or patients' conditions (e.g., before or after meals, before sleeping time, and so on)
• Busy nurses working in a highly interruptive environment may miss important information while administering drugs	• Detailed information on each MO label, written in small letters and black ink; although highly legible, the labels burden nurses with a high cognitive overload with regard to reading them carefully	• To emphasize the most important information such as the stop date or the comment section with a highlighter pen on the MO label
5. Monitoring		
• Wrong or incomplete sets of MO labels on patients' Kardex cards • The nurse may easily mistake look-alike information such as patients' names and then puts the wrong MO labels on the wrong patient's Kardex card	• Printer dysfunction or MO labels lost among other papers in the station • MO labels of different patients are printed at the same time in a mixed order with no easily distinguishable visual clues between them • A high cognitive overload on nurses with respect to separating MO labels of different patients and reading them carefully, due to the materiality of each single MO label to be affixed to the correct Kardex card and to look-alike MO labels containing information items in very small print	• Double-checking of MO labels in the Kardex card with the AMO every 24 h • Putting a reminder in the station for nurses to alert them with regard to patients' names that are similar
• Lack of temporal overview regarding the period of medication use; a patient receives a drug that should have been stopped earlier	• Usability issues: for physicians, getting a temporal overview of the medications is not easy on the screen • Getting an overview of the administration data is not easy during morning rounds or in the time of order entry. This makes the monitoring of medications for physicians very difficult	• Nurses remind or call physicians if they notice such issues
• Flawed monitoring mainly because the drug administration data is not practically available either during the morning round or at the time the physician enters the order	• The Kardex cards, which contain administration information, are affixed to a movable medicine cart that is generally left in the medication room	• Before morning rounds, physicians may have briefing sessions among themselves to verbally communicate the most critical events that happened the previous night • Physicians mainly rely on nurses' memory and their verbal communication of the administration information

categories in our study namely *difficulties* in each phase and the *responses* to address them. Finally, we used an axial coding technique to link between the probable root causes and the difficulties and the responses. To identify workarounds developed in this case study, we used our definition of a workaround presented earlier: informal rules or work methods – not formally considered and outlined in the system design – employed in working with a system to handle a workflow problem.

During the data collection period, the first two authors transcribed and analyzed each interview before conducting a new one. This helped to organize the questions for the consequent interviews and to check the validity of our preliminary interpretations with the participants. The overall data analysis for the present study was then conducted by the first two authors and the findings were discussed among the other authors. The correctness of the interpretations was also checked with the members of the implementation team (i.e., the project manager and the helpdesk). "Atlas Ti" software was used to assist in analysis of the data set. In the next section, we present the major themes that emerged in the majority of interviews.

4. Findings

We present our findings based on the five phases in the medication-use cycle (Fig. 4). In each of these phases, we focus on the problems – interruptions and workflow blocks – encountered and on the workarounds devised to cope with them. It is noteworthy that in real practice these phases are highly interrelated and they overlap without a clear-cut distinction between them. For example, issues in the prescribing phase may partly overlap with those in the monitoring phase. Table 1 provides details of the problems encountered, their probable root causes, and the resulting workarounds that emerged to address them.

Our analysis shows that the majority of reported problems were in the communication and prescription phases, respectively. It also indicates that the use of workarounds and variation in their types were more evident in the communication, administration, and dispensing phases. We will schematically show some of the breakdowns in workflow, workarounds devised to address them, and certain new organizational rules defined after the implementation in Figs. 5–7.

4.1. *Prescribing*

Physicians visit their patients with nurses during morning rounds. Because the CPOE system is not accessible at patients' bedsides, physicians may first check the patient medication record in the system in their offices and take a hand-written summary to the bedside. Otherwise, they may rely on the AMO lists. Mostly, however, they rely on their memory, especially when the patient has been in the hospital for a few days (Fig. 5). An AMO is primarily used by nurses who decide which kind to print in a given ward. Because different AMO lists contain different information, the one-day AMO printed by nurses may not meet the information needs of physicians. One physician noted:

> *"... we use a printout [the one-day AMO printed b y nurses in his ward] that is archived in the nursing file. And we look at it and see what a patient is using today, but 'what was he using yesterday?' The answer is 'I don't know!'". (P1*[1]*)*

After the rounds, physicians return to their offices and enter the electronic medication orders. During medical rounds, in order to avoid interruptions caused by physicians needing to travel to their offices to enter orders for each patient, physicians may take a brief note of orders on paper or rely on memory. In busy wards with a number of patients and numerous changes in orders, this may cause problems. An attending physician explained the situation as follows:

> *"My main worry, especially with regard to the junior doctors, is that you ask a great deal from them. When they are attending with me here for the first day, I ask them to make round for 16 patients. And they have to know after 16th patient exactly what they want to change in the medication of the first patient. That is what I am asking from them. ... During the round you cannot walk from the bedside to Medicator [the former name of Medicatie/EVS® that is still used in the hospital]. So, when the system was introduced, that was signaled as something that would be a problem; then we got the friendly and very specific answer that 'the problem is known and in the future we will look to see how to solve it."' (P1)*

According to a formal agreement, after the CPOE implementation, nurses should not accept hand-written medication orders. However, to organize their daily nursing work after the medical rounds – and before physicians are able to issue the electronic orders – it is possible that nurses ask physicians to issue temporary medication orders on paper. The main reason, as nurses reported, is that it may take a few hours before physicians enter electronic orders. Nurses associated this mainly with the time pressure that results because physicians are committed to other clinical duties after the medical rounds: for example, the coverage of emergency patients in their daily shifts, outpatient visits, operations, or educational responsibilities. A number of physicians also referred to issuing paper-based orders but associated that also with patient safety practice: administering the right medication timely. A physician told us:

> *"... we have two systems for ordering: stickers [MO labels] by Medicator and also you write them down, because [for example] it is possible that I make an order in Medicator but it is not coming out from the printer. And then nobody knows that the patient should get the medication, and that is why we write it down and we make a print." (P3)*

Similarly, it is possible that new patients are admitted after medical rounds or during evening shifts when physicians are busy. Because these patients are mostly using a number of medications at the time of admission, it is time-consuming for physicians to enter them into the CPOE system if they had not been admitted to this hospital on previous occasions or

[1] "P" stands for "physician" "Ph" for "pharmacist", "PhT" for "pharmacy technician" and "N" for "nurse". The interviewees' numbers are based on the alphabetical order of their names to preserve confidentiality.

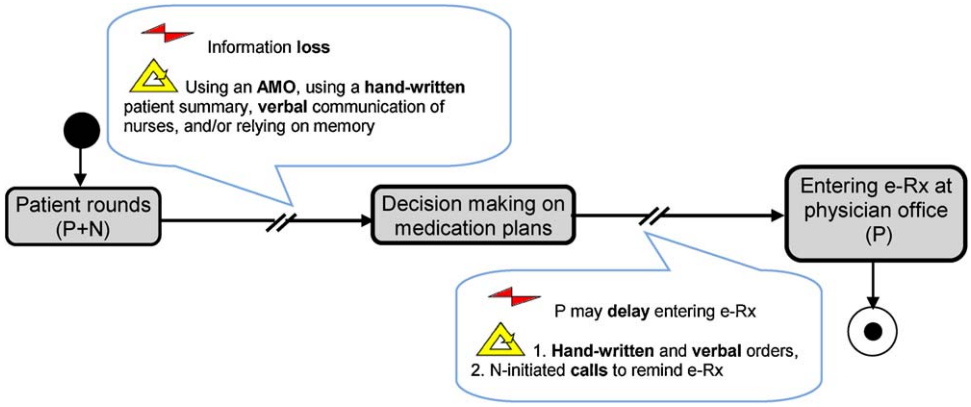

Fig. 5 – Examples of problems and workarounds seen in the prescribing phase due to lack of bedside systems (: breakdowns in workflow; : workarounds; P: physician; N: nurse; AMO: a printed list of patient latest medication orders; e-Rx: electronic orders). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

if their orders are not entered in the CPOE system in ambulatory care clinics of the hospital. Therefore, in response to the nurses' telephone requests for medication orders, according to an informal agreement between physicians and nurses, for most important and urgent medications, physicians may give verbal orders or issue short paper-based orders on the appointment forms. However, the formalized hospital rule is that verbal orders should be used only when physicians are on call and outside the hospital and then are unable to enter orders into the CPOE system.

4.2. *Communication of orders*

Both physicians and nurses reported a number of problematic issues that emerged in their communication. As mentioned earlier, physicians may be forced to communicate orders verbally and/or through paper-based orders before issuing the electronic orders. A nurse commenting on verbal orders told us:

> *"... when physicians are not available, they can give oral orders and then we give the necessary drugs to the patient. However, it has to be registered somewhere. Nurses may want the physicians to enter orders into Medicator later and issue stickers afterwards. This is very important in order to make the process legal." (N11)*

In the event that physicians delay entering electronic orders or enter new orders that are not expected by nurses, they need to tell nurses directly or call them (Fig. 6). This is mainly because, apart from seeing the printed MO labels, there is no other order notification for nurses such as actually observing the physician enter an order or a list of newly entered orders. As nurses are busy with care activities in patients' rooms or elsewhere, they may notice the labels only later in the day. To address this issue, the implementation team made two rules during the implementation process: first, after any new electronic order entry, physicians should notify the responsible nurses either face-to-face or by means of a phone call, and the second, nurses should check the printers for new orders before they start their rounds of drug administration. However, with regard to the first rule, as nurses declared, it largely depends on which physician is on duty and how busy s/he is. Nevertheless, it became evident that physicians may not perceive this extra task as a fixed rule. A physician told us:

> *"... I enter a prescription in this computer and I order the print in another location. The nurses will get it and see it is prescribed by a physician. [Then] it is ok and there is no problem. ... But, I think it is polite to call them. In our department, it doesn't matter whether I call or not; it will work. And if the nurses aren't sure, they will call me then". (P6)*

Similarly, communicating orders only by electronic means carries the risk of a miscommunication of ideas. To address this, clinicians use added communicative methods such as extra face-to-face contact and phone calls. As mentioned earlier, the lack of bedside possibilities to issue electronic orders promptly after each patient visit delays the order entry process and forces physicians to rely on their memory or on their brief paper-based notes. This can result in physicians entering an order different from what had been decided upon earlier – and that nurses had written in their notes – during morning rounds. This forces nurses to seek more clarification from physicians.

Furthermore, nurses receive a number of highly detailed MO labels, printed in black ink on a small sticker, making them all look alike. These labels lack visual clues to identify their special items. Therefore, if a special issue arises, such as the administration of a drug outside of the routine time, physicians need to call nurses to ask verbally for special attention to be paid to the matter.

4.3. *Dispensing*

Erasmus University Medical Center has two systems of drug dispensing in clinical units: one for frequently used medications (in-stock) and the other for rarely used medications (non-stock). In-stock medications are controlled by the pharmacy technicians two or three times a week by scanning the drugs in the ward stocks. The logistics of ward stocks is based on a scientific analysis of supply and demand on a yearly basis as well as on the cost of the drugs, their expiry dates, and

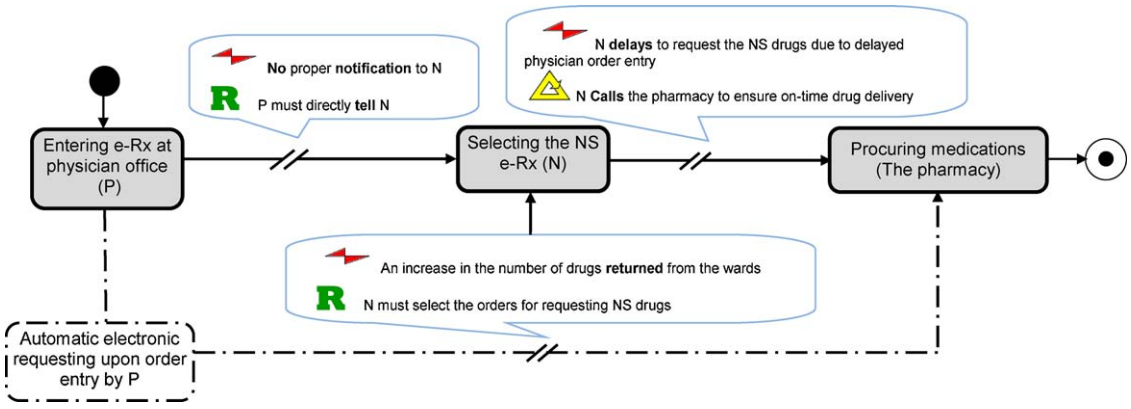

Fig. 6 – Examples of problems and workarounds seen in the communication and dispensing phases. The broken lines represent the older sub-process (R : a new organizational rule). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

the limited physical space available at the wards. In this way the pharmacy has been able to efficiently control the costs of in-stock drug supplies. However, nurses complained about the shortages of their in-stock supply caused by the flow of patients using specific drugs more than usual. Meanwhile, because of the concern that electronic requests for in-stock drugs would generally be rejected by the pharmacy department, the nurses overcome the shortage by borrowing from the in-stock supply of other departments. This informal process occurs especially during evening or night shifts.

In the first year of implementation, the medication orders that physicians entered into the system were automatically put on the drug delivery list that was accessed by the pharmacy department. This in fact removed the workload of nurses in the pre-CPOE implementation phase to type the needed non-stock requests into the hospital information system (and then to put them on the pharmacy's drug delivery list) or to take the paper requests to the pharmacy. Similarly, the pharmacy technicians did not need to transcribe the orders and then enter them into the pharmacy system. However, both clinical wards and the pharmacy department experienced problems because of this functionality during the early months after implementation. As a result, they both agreed to turn off this function of the system.

All electronic non-stock medication orders were automatically put in the "order request list" of the pharmacy system. The pharmacy sent these medications to the wards after checking the request list. When physicians changed these non-stock orders, the pharmacy received these changes as pending requests that had to be fulfilled. For example, if a physician had ordered a non-stock drug once a day for a patient, a whole box of the drug would have been delivered to the ward. This was mainly done because delivery of whole boxes did not require extra labelling of boxes and could be handled by personnel without pharmaceutical training. However, patient deliveries should contain a label with the patient information, which in turn required pharmacy technician involvement. As a result, if the dosage was changed: for example, three times for a drug during a patient's stay, the pharmacy department would have delivered three boxes of the drug because any change in the dosage was configured as a new request by the system. As a result, nurses had to return the remaining drugs (i.e., many intact boxes) to the pharmacy.

The pharmacy department also experienced that many of the non-stock drugs delivered to the wards were returned to the pharmacy without actually being used. Handling the high number of returned drugs in fact added to the workload of both the nurses and the pharmacy. The implementation team, the pharmacy department, and the nurses therefore agreed to stop using the automatic transfer of requests. Instead, nurses now have to electronically select those non-stock electronic medication orders that are necessary for their patients, as they used to do before CPOE implementation. Only when nurses select these orders in the system, electronic requests are sent to the pharmacy. Although the involvement of nurses in requesting non-stock orders has solved the problem of controlling the drug supply, the work condition in the wards after implementation (e.g., delayed electronic order entry by physicians) still remains a source of frustration.

To cope with the high workload in managing the drug supply for the entire hospital during the course of a day (wholesaler deliveries), the pharmacy technicians normally check the requests per patient per wards twice a day: at 8 a.m. and 12 p.m. After these checks, the technicians provide the wards with their non-stock drugs in patient-labelled minigrip (zip-lock), plastic bags for 5 days, based on average duration of hospital stay. For safety reasons (i.e., nurses requesting and administering incorrect drugs), any non-stock drug request without the corresponding patient identification would generally be cancelled by the technicians. In the meantime, if the requests are sent during the afternoon – mainly due to physicians who delay entering orders into the system – nurses also need to call the pharmacy to ensure a timely drug delivery. As one head nurse noted, every nurse needs to know this, and if a busy nurse does not pay particular attention to the time at which she requests the drugs, they will be delivered the next day. While the management of non-stock medications has been found problematic by nurses, the pharmacy does not perceive it as a pressing issue. In this regard, a pharmacist told us:

> *"Normally, they (non-stock medications) are home medications and the patients are asked to bring them to the hospital. So this should not be a problem." (Ph2)*

Meanwhile, a nurse noted:

> *"For the patients coming from home, we need to request and prepare all their medications [both home medications and those started at the hospital] from the pharmacy department before the next shift arrives the following morning." (N10)*

Also complex is the management of expensive drugs, antibiotics with restriction, non-formulary drugs that are a second choice if started in the hospital, and drugs that are not delivered without an accompanying explanation because of safety concerns. Some drug orders should be accompanied with an explanation because they are not available in the pharmacy and require procurement from the wholesaler or they are not registered in the Netherlands. In these instances, during the order entry phase, physicians are asked to document their reasons for prescription. When confronted with orders such as home medications, the pharmacy technicians first call nurses to inquire whether the patient has brought them in. If not, the pharmacists are then involved to evaluate these orders and, if it is the case, to call physicians and suggest an alternative available in the hospital. However, it often happens that these orders are coordinated only through verbal communication and then the physicians forget to change them in the system. To avoid repeating the procedure when the same requests are received from nurses, the pharmacy technicians are using a simple computerized database in their own system:

> *"We enter the order requests in there and whatever actions we take, for example, calling the nurses, calling doctors and proposing an alternative by the pharmacist, we enter all of these into this program. In that way, if we get the same request next time, we can look back at the history to see what we have done or what our colleague has done in that instance". (PhT)*

Although information is typed into this program by the technicians, this has been perceived as less time-consuming, less disturbing, and more efficient in the information transfer in the big group of pharmacy technicians when compared to normal calls to the wards.

4.4. *Administration*

In theory, nurses should wait for MO labels and then administer drugs on the basis of them. They then record the administration by signing next to these labels on the Kardex cards. In this way, nurses do not need to transcribe the physician-written orders for documentation purposes. However, their work depends largely on the complete and timely availability of these labels at the time of administration.

In nearly all the wards in which we interviewed, it was reported that nurses sometimes start administering drugs that are available in the ward stock even before receiving the corresponding electronic orders and their printouts from physicians. Their reference for administration is the verbal and/or the concise paper-based orders that have been issued by physicians during medical rounds. Alternatively, they may refer to their own notes taken during these rounds. For documenting the administration, they manually write these orders where their corresponding MO labels will be affixed. However, they consider their work incomplete if they do not receive the printouts of the electronic medication orders for documentation purposes. To be complete, they call back physicians to remind them to enter the electronic orders:

> *"... but sometimes you have to call and remind them that it is already 2 or 3 hours later and you have still not received the labels. This costs us a lot of extra time because we never forget and we always have in mind that we gave the medications to the patients but have not yet received the labels". (N10)*

One issue that emerged during the interviews was that it is possible that the nurse taking part in the medical round is not the nurse who administers the next round of medications. In such cases, the verbal communication between nurses to coordinate the administration of a drug plays an important role. However, because of its mostly verbal nature, the efficiency of this communication in terms of transferring the changes in orders precisely is questionable.

Furthermore, nurses may experience some discrepancies between the physician-initiated orders and ward routine or the patient's condition when they are planning to administer drugs. To resolve such discrepancies, nurses may need to modify the orders. This is evident especially with regard to the time of administration, although every ward has its own drug administration times presented by the CPOE. To adjust the orders at the time of administration, it is possible that nurses go to the nursing station, log into the system, and change the time and print a new MO label. However, this would interrupt their activities at times when concentration is highly necessary. To avoid this interruption, they simply cross out the items and add new ones that best comply with the situation (e.g., before or after a patient has eaten, before sleeping, and so on) (Fig. 7). However, an important point is that these changes by nurses are only registered on the labels and not in the CPOE system. More importantly, they are not communicated to the physicians.

Moreover, because of the highly structured and look-alike nature of orders, nurses highlight the most important information on each MO label with a highlighter pen so that it will not be missed by them or their colleagues. They may also annotate the administration records themselves to create some visual clues as recommended by the implementation team. For example, to highlight a "stop" date, they may use a colorful marker to write "stop" in large letters, use a colorful stamp with a "stop" sign, or put a cross next to the dates on the Kardex card, indicating in advance that the drug should be discontinued. Both types of handling stop dates were proposed by the Medicator team during implementation because any adjustment of MO labels was not feasible.

4.5. *Monitoring*

Monitoring of the medication plan may be done by nurses and physicians. Nurses reported cases of patients who had incomplete or wrong MO label sets on their Kardex cards. Our informants attributed this to different root causes. First, it is possible that the printer fails to print the MO labels because of a technical problem. Second, after MO labels are printed, it is possible that they get lost among other papers in the nursing station or they may have been left forgotten in the pockets of busy nurses. Third, at the time of affixing labels

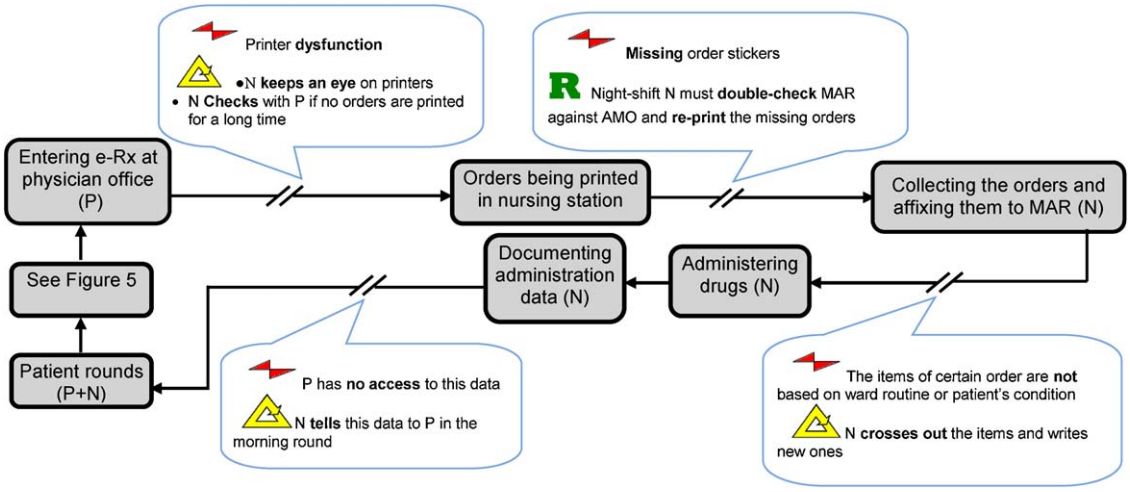

Fig. 7 – Examples of problems and workarounds seen in the communication, administration, and monitoring phases (MAR: medication administration record).

onto the Kardex cards, nurses may make mistakes because of look-alike labels and very small information items or because of their hectic workstations (e.g., a question from a colleague while labels are being placed). Since these problems were known and witnessed, during the implementation phase, the Medicator team set a rule for the double-checking of medication orders every 24 h. For double-checking, mostly the night shifts (in only a few wards, the day shifts) check the order labels affixed to the Kardex cards against the AMO (the list of the patient's latest medication orders). The AMO is printed after midnight because then the date on the AMO will be the same as the day when the nurse uses AMO for discussion in the morning round. These checks therefore take place after midnight when nurses are less busy but generally tired and less alert.

Despite the double-checking every 24 h, nurses reported instances in which a drug had already been started by a physician but after a few days it was not shown on the Kardex card: this resulted in it not being started on time. Such issues are important because if a physician forgets to enter an order the nurse may follow up the order based on her notes or on the physician's verbal orders; however, if nurses do not start or stop medications on time, there is no way for physicians to notice and monitor that. This is mainly because their practical reference for the medication plan is the CPOE system and its printout and not the administration records. The administration records are affixed on a moveable medicine cart that is normally left in the medication room, where physicians do not enter orders. Therefore, physicians need to contact nurses directly or look for Kardex cards themselves.

5. Discussion

Our study deals with the impact of CPOE use on workflow, and reasons for problems that occurred, and for workarounds. The problems in the post-CPOE medication process differed in their nature and affected one or more providers (Table 1). They included cognitive overload on physicians in the decision-making phase (e.g., to recall patient information from the memory) and their unmet information needs, miscommunication of orders and ideas between physicians and nurses, problematic coordination of interrelated tasks between co-working professionals leading to delayed tasks, potentially faulty administration phases with high cognitive overload on nurses (e.g., checking a number of look-alike MO labels for each patient in a limited time), and suboptimal monitoring of the medication plans by providers. These problems were mainly rooted in the lack of mobile computer devices, the uneasy integration of coexisting electronic and paper-based systems in the correlated phases, the usability issues of the system (e.g., the lack of a quick overview on the latest orders and requests), and certain organizational factors affecting the technology use such as the complex logistics of procuring drugs in the hospital.

To address the problems, the work organization devised various types of workarounds including many phone calls within and between professional groups, taking multiple paper notes that summarized the information in the system or the decisions made, issuing paper-based and verbal orders, double-checking, using other patients' procured drugs or another department's drug supply, using paper notes or computer-based programs to coordinate exceptions within the professional groups, and modifying and annotating the printed orders to appropriate them in routine practice. Some of the workarounds such as non-stock order requests or double-checking by nurses were defined as organizational rules. Moreover, workarounds such as nurse-initiated calls or direct communication were aimed at accelerating the performance of interrelated tasks, while others such as physician-initiated calls or the double-checking of orders were devised for better safety features in the integration between the CPOE system and the paper-based administration system. These workarounds affected clinical workflow

to varying degrees: some eased and accelerated the performance of tasks while others burdened already busy providers with an extra workload. Although the providers in our study recognized the workload caused by these workarounds, they valued highly the *situatedness* of them to overcome local obstacles and considered them necessary for the efficient functioning of their medication process.

In accordance with the findings of Vogelsmeier and colleagues [11], we identified workarounds related to workflow barriers introduced by technology and its technical components: these included the lack of mobile computer devices, printer dysfunction, and an underlying assumption in the system that any change in an order constitutes a new order. We also identified workarounds related to organizational processes not reengineered to effectively integrate with the technology such as making the administration records more accessible for physicians and nurses at the time of decision making. More importantly, we found that these two patterns of workarounds are intertwined in practice: one pattern influences and is influenced by the emergence of the other. As we saw in our study, the linking of a number of social, technical, and organizational factors influenced the development of the workarounds. For example, the lack of mobile computer devices and the concomitant delay in order entry by physicians, the lack of proper and timely notification of the latest orders for nurses through the system, the need for nurse-initiated electronic requests in the clinical wards, the lack of proper notification of the latest electronic requests to the pharmacy technicians through the system, and the internal policy at the pharmacy with regard to when to check these requests influenced the emergence of additional calls made by nurses to the pharmacy following each non-stock drug request. Moreover, our findings confirm those of Kobayashi and colleagues [21]: namely, to stabilize workflow, the development of a workaround may have a cascading effect initiating a series of further workarounds (e.g., nurse involvement to request the non-stock orders was followed by phone calls to the pharmacy to ensure timely drug delivery, mainly due to their perceived necessity).

Very similar to Georgiou and colleagues' study [10], at our study site too, the terminological difference between "orders" and "requests" resulted in some organizational dysfunctions in both the clinical wards and in the pharmacy department. The drug delivery following each order entry by physicians for non-stock drugs resulted in a very high percentage of returned drugs from the wards. To manage this problem, the pharmacy switched from checking automatic requests based on physician orders to checking nurse requests. Nurses easily adopted this order-requesting method, first because there was not any immediate technical solution for that, and second because it was similar to what they had been doing in their paper-based system. Therefore, a tacit knowledge of work guided the work organization to consider this method. Nevertheless, the lack of mobile computer devices compounded the problem: the system was also accompanied by a delay on the part of physicians to enter orders in contrast to the paper-based system, in which immediately after the morning rounds nurses had all medication orders at hand to start requesting. To accommodate workflow at the pharmacy following delayed electronic requests, a technical solution such as a proper computerized notification of the latest requests of all wards together may have been helpful in facilitating the awareness.

The implementation team in this hospital had been busy collecting information on the actual use of the system since the implementation time. However, some of the findings in our formal and qualitative evaluation of the context of CPOE were rather new and surprising for the team. One of the practical results of this study was considering some changes in the training sessions for clinical end-users and highlighting and discussing the important issues of the post-CPOE medication process (e.g., the pros and cons of different AMOs in satisfying information needs). Also, to address the problems, some customizations in the system were requested from the vendor. Moreover, informed by our findings, the hospital started a selecting procedure for new IT-systems such as electronic medication administration registration that can be better integrated with the local workflows and can cover some of the present problems.

Our qualitative data indicates that the workarounds used in the prescribing, communication, and the administration phases may have had the most negative effects on patient safety. For example, the electronic system was implemented to intentionally cease the paper and verbal orders. However, as seen in certain circumstances, the context of CPOE use compelled the providers to bypass it. Verbal orders then were still frequently used, although it is supposed that the implementation of CPOE systems should decrease their number significantly [24,25]. The fact that these verbal orders are entered *only later* by the responsible physician or even his/her colleagues simply for documentation purposes (*if not entirely forgotten*) questions the high hope of CPOE's beneficial impact on patient safety. Our study also demonstrates that neatly documented orders in a CPOE system may not thoroughly represent what has happened in real practice. Our findings therefore challenge the value of the retrospective studies of medical errors and quality of care with these systems. Workflow and medication errors should be studied in prospective, multi-method studies.

The need for timely and proper notification of orders to the providers intended has long been recognized in CPOE studies [26]. Health care professionals are busy and mobile, working mainly in places other than around computers and printers. CPOE systems are often accompanied by a lack of visual clues to identify new orders, such as the presence of a physician at a bedside or the physical existence of paper orders or requests. To maintain awareness, a number of solutions have been suggested in the literature including real-time, visual alerts and electronic inpatient whiteboards [27,28]. However, the providers' different clinical roles, clinical tasks, and working places should be seriously taken into account in using such solutions.

Our study revealed that how the work organization was actively involved in contextualizing the system in the medication-use cycle by accommodating local conditions [18]. It is already known that the effectiveness of CPOE systems to a large extent depends on how this process and its associated

challenges are approached and dealt with [10,17]. However, the changes required and the workarounds developed to facilitate workflow happen in unexpected ways, which calls for careful management of change processes. One reason is that clinical providers, who are involved in this "contextualization", might choose feasible solutions based on their tacit knowledge of work: however, these solutions might be in conflict with other aspects of work in the same or other work units in a hospital [29].

To foster boundary-spanning support, especially when innovations cross boundaries, Tucker and Edmondson proposed having "problem solving coordinators" [22]. However, for professional information management in an HIT implementation environment, such coordinators need to have a solid background in health/medical informatics or to work closely with well educated health/medical informaticians in a skilled and multidisciplinary research team. Such approaches will enable studying and analyzing the pre- and post-CPOE work structures and also finding solutions that benefit all parties involved in a productive way. The overall approach to managing change should incorporate both the redesigning of the systems as well as the work processes to ensure that: firstly the systems are more compatible with the hectic work environment of providers; secondly, the usability are improved for quick and genuine order entry and data registry; and finally, patient data and also the interrelated tasks of co-working providers are adequately integrated to support clinical workflow. In fact, to develop work-affording systems, "co-realization" [30] and "evolution-in-use" [31] in the context of actual use can be promising.

5.1. *Limitations of the study*

Our findings relate to the context of CPOE use in one medical center. Because of different socio-technical systems emerging as a result of interaction between HITs and their implementation environments, these findings may not be generalizable to other settings. Yet, our study provides some key information that may assist other hospitals how to plan, and to evaluate their CPOE context more critically, in order to identify and prevent "workarounds" that burden providers (e.g., extra time and effort being required) or endanger patient safety. Next, our participants were chosen among the key informant users, who acted as a link between the implementation team and the clinical end-users. Because of this purposeful sampling, we cannot be sure of the representativeness of their views. Most of our study participants were pleased with the many advantages of the post-CPOE medication process. In the meantime, however, they also highlighted the problems faced, hoping to find a solution for them. The present study focuses on analyzing these problems and not on the advantages. Therefore our study should not be construed as presenting simply the negative effects of such systems. Moreover, in this study we did not make a direct comparison with the pre-implementation medication process, mainly because the interviews were conducted at least one and half years after the implementation, thus making it difficult for interviewees to make a precise comparison. Hence it is possible that some of the problems might have been present in the pre-implementation phase and were not the result of the CPOE implementation.

Summary points

What was known before the study:

- There is a growing concern about how and with what consequences CPOE systems are operational in successful implementation sites.
- Changes in work practices after implementing CPOE systems in certain instances can introduce problems in clinical workflow. New organizational rules are introduced and workarounds are devised to cope with them.
- Workarounds developed in the use of CPOE systems may blur the underneath workflow problems generated by these systems. The reasons behind the generation of workarounds as well as their side effects on clinical workflow merit more attention.

What the study has added to the body of knowledge:

- The situatedness of workarounds to overcome local obstacles makes care providers to value them highly despite the workload that they bring along.
- Workarounds devised by the members of one health care professional group might be in conflict with other aspects of their own work or with the work of other professional groups.
- To find workable and balanced solutions that serve all professional groups involved in a clinical process, a problem solving coordinator with a solid background in health/medical informatics can play an effective role.

6. Conclusion

Our study further reinforces the complexity of the medication-use process in a CPOE context that connects providers from different professional groups within and between departments and their competing interests and conflicts. It shows how the features of a CPOE system affect and are affected by the work practice over time. It demonstrates that providers are actively involved in bypassing the technology or in adapting the work process to cope with difficulties in their workflow. This in many instances takes the form of a workaround that providers devise for good reasons: to maintain a smooth workflow and/or to ensure patient safety. However, in certain instances these workarounds burden providers with extra time and effort or endanger patient safety. It is important that the workarounds of a negative nature are recognized and discussed with the parties involved in order to find solutions to mitigate negative effects.

To conclude, one can find unsuccessful components within successful implementation sites where CPOE systems are operational in daily practice. Our formal examination of use of workarounds, and their effects on workflow, provides important insights into an approach which is probably widely used in practice, but little examined. Our findings call implementers

and evaluators to pay closer attention to recognizing and addressing such issues in actual practice in order to reap a CPOE system's full benefits. Insight into these contextual issues can help them to understand the *in situ* operation of a CPOE system in its use context and help to design strategies to lessen the number of disruptions in workflow and their possible negative consequences.

Authors' contributions

ZN and HP collected data. ZN designed the study, analyzed data, and wrote the early draft of the manuscript. HP assisted in the analysis of data and was also involved in critical review of the content. HS and JA critically reviewed the manuscript and commented on that.

Conflict of interests

HS was the project manager of the CPOE implementation team in this hospital. The opinions reported in this paper are those of the authors. The authors declare that they have no competing interests.

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