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Medication quality and work practice

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Abstract

Supported by digital systems, closed loop medication management (CLMM) is considered an essential method to improve the quality of medication management in hospitals. This includes electronic ordering, verifying, preparing and administering medication. However, healthcare has so far seen very few fully working solutions of CLMM. We therefore pose the research question: What is the nature, challenges and consequences of CLMM in hospitals? We find that CLMM is highly resource demanding and implies a lot of engagement and workaround by health personnel. While some workaround are expected, we find that others may jeopardize patient safety. The paper contributes with an understanding and conceptualization of CLMM and proposes socio-technical strategies for using digital tools to increase the quality of the medication management process. Theoretically, we draw on the concept of information infrastructures, work practice perspectives and work system theory. Empirically, we present a study of the first hospital in Norway to have implemented CLMM.

Keywords: Closed loop medication management; barcode; medication; work practice; workaround; electronic medication management system

1. Introduction

Medications errors can occur at any stage of the entire medication management process, from prescribing,

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documenting, transcribing, and dispensing, to preparing, administering and monitoring [1]. This prompts a focus on how to prevent such errors especially by introducing digital systems that can contribute to closed loop medication management (CLMM) in hospitals. CLMM aims to increase patient safety and quality by decision support in the medication management processes, and to ensure the patient´s identity, and correct medication by using electronic barcodes. CLMM is considered the gold standard in medication management, and is supported by digital tools.

However, healthcare has faced calls for CLMM for several decades, but has, so far, seen very few full solutions that includes the totality of all medications [2]–[5]. Part of the problem appears to be the lack of a clear definition of CLMM. While there is general agreement that digital systems should ensure that the right patient receives the right drug in the right dose at the right time through the right route, actual implementations seem to raise several questions. For instance, it is not clear what kind of decision support is required, what the "right" drug means, and what proportion of the medication must be included in the closed loop before the hospital can claim that CLMM is achieved.

Further, the information systems field has frequently pointed out that implementing complex and collaborative new technologies in healthcare is notoriously difficult. This is also the case with digital systems needed to support a CLMM. The major digital tool in question, is an electronic medication management system (eMMS) where it should be possible to electronically identify both the medication and the patients in key steps of the medication process. In addition to the eMMS, there are typically several other systems in the hospital that need to play seamlessly with the eMMS, most notably, the electronic health record (EHR), and medication stock keeping systems. Thus, having implemented a CLMM means that different healthcare workers need to have documented each step in the medication cycle electronically and have to engage with various systems in the process. Thus, there are many socio-technical concerns in the CLMM implementation process that are important to consider.

Based on this, we ask the following research question: *What are the nature, challenges and consequences of CLMM in hospitals?* Specifically, our discussion proceeds along the following three dimensions: First, we elaborate what characterizes CLMM and how digital tools can support it. Second, we explore the kind of *work* that is necessary for a successful CLMM. Third, we discuss how quality is affected in the medication process. The paper contributes to an understanding and conceptualization of CLMM in hospitals. It also provides strategies on increasing the quality of the medication management process with digital tools.

Drawing on interpretive research methods, we have studied Kalnes Hospital in the South-east health region in Norway. Kalnes is a top modern hospital that received its first patients in 2015. The hospital was the first to decide to implement CLMM in Norway. Conceptually, we draw on the concept of information infrastructures and work system theory due to the involvement of many existing systems needed to support the CLMM, the heterogeneous work practices and the necessity of taking a holistic approach.

2. Theoretical foundations

Ensuring high quality treatment and care is a pressing issue for health authorities. In a 2000 US Institute of Medicine report, the Committee on Quality of Health Care in America estimated that medical errors were the leading cause of death in the United States [6]. Medical errors are generally associated with an increased burden of illness for patients and increased expenditures for hospital treatment [7]. In Norway, 5–10 % of admissions to internal medicine wards are caused by improper use of drugs. Medication errors occur in 20 % of all patient treatment pathways and is associated with expenses estimated as 5 billion NOK each year [7]. A consequence is that a minimum of 1000 patients die each year from adverse drug reactions and improper drug use in Norway [8].

The World Health Organization (WHO) launched in 2017 a global initiative to reduce medication-related errors by 50 % over 5 years [9]. In this regard, there is a general perception both from most healthcare professionals and from authorities that an eMMS with support for CLMM can address the issues mentioned above, and thereby improve the quality of the patient treatment. For instance, the Australian commission on safety and quality in healthcare argues that the number of dispensing errors will decrease through a closed-loop medication ordering, automation and barcode scanning system [10]. There are similar viewpoints in Norway [11], and other countries in Europe [12] [13].

Nevertheless, CLMM presents as a slippery notion. Bowles & Lu [14] argue that CLMM is being incorrectly conceptualised as a linear process from the pharmacist to the patient. If the aim of CLMM is to manage risks associated with potential causes of harm to a patient, such actions need to occur not just at each point in the process but across all points in the process's lifecycle. They claim that the existing CLMM systems fail to include pre-

pharmacy packing and supply from the manufacturer, as well as follow-up and prescription renewal stages after delivery of the medication to the patient [14]. In comparison, Ovesen et al. [15] define CLMM as an electronically supported process of medication management where information from ordering to the point of administration is transferred seamlessly between different digital systems. Here, CLMM follows a single medication unit that is electronically documented and therefore easy to trace. However, a limitation is that not all of a patient's medication is necessarily part of the CLMM. This begs the question of what kind of drugs are excluded in the CLMM, whether these are high risk or not, and how the management of the excluded drugs is quality assured. Another point is that interaction support is frequently missing in current definitions of CLMM. A drug interaction is a change in a drug's effect on the body when the drug is taken together with a second drug. This can decrease or increase the action of both drugs, cause adverse effects, decrease or block effects. Choosing the optimal drug for the patient and educating the patient on the correct use and to avoid or handle drug interaction are all important factors to ensure patient safety.

The uncertainty around what CLMM entails, and how quality is achieved, can motivate moving away from CLMM as a clearly defined concept, and rather focus on how CLMM is achieved in practice as a collective socio-technical commitment. This means focusing on how the health personnel engage with both new and existing technologies to achieve CLMM and how this ultimately affects the quality of the medication management process. CLMM represents a highly distributed process where work tasks and several supporting digital systems are entangled and interconnected to each other [16], and where each step in the medication loop is crucial for ensuring patient safety. This includes decision support when prescribing medication, involvement and education of the patient, and observation and evaluation of the drug treatment. The systems involved in medication management are an eMMS, EHRs, stock-keeping systems, chemotherapy systems, etc.

Accordingly, accomplishing CLMM may put a lot of responsibility on the health personnel. They must engage with digital systems to make things work as well as for ensuring the quality of the medication cycle. In a complex work practice such as medication management, situations may arise where the technology being implemented does not fit as intended, particularly since some system entails quite rigid work routines (for instance barcode scanning of the patient and the medication dose at several steps) and where users are assigned tasks in a standardized way. In this regard, a lot of studies point to how users have to adapt to a "rigid" technology in various ways, for instance by workarounds [17] or new routines [18]. Alter [19] defines a workaround as a goal-driven adaption, improvisation, or other change to one or more aspects of an existing work system in order to overcome, bypass, or minimize the impact of obstacles, exceptions, anomalies, mishaps, established practices, management expectations, or structural constraints that are perceived as preventing that work systems or its participants from achieving the desired level of efficiency, effectiveness, or other organizational or personal goals. In a study by Pollock [20], workaround is conceptualized as routine adaption, implying that workaround is not an act of compensation for design failures, but rather an inherent and constitutive part of any use of technology.

Given how several digital systems are supposed to support CLMM and the implicated work practices, we turn to the notion of information infrastructure (II) and work system theory (WST). II is a theoretical framework that can be used to improve our understanding of the dynamic relationship and interaction between actors and artefacts in collaborative practices [21]–[23]. In this perspective, technology cannot be separated from social and other non-technological elements [24]. Star and Ruhleder [22] describe infrastructure as a fundamentally relational concept that occurs in the relation to organized practises. Pipek & Wulf [25] illustrate that the infrastructure of a worker or organization is the entirety of devices, tools, technologies, standards, conventions, and protocols on which the individual worker or the collective rely to perform the tasks and achieve the goals assigned to them [25]. An II typically inhabits an enabling character, which in our study reflects how several digital systems and associated work practices may support the CLMM.

WST is a perspective for understanding work systems in organizations. A work system is a system in which human participants and/or machines perform work using information, technology and other resources to produce product/services for customers [26]. Work systems are sociotechnical systems in which people perform processes and activities, and differs from other viewpoints where the system is a computerized artefact that is used by users [26]. WST describes a dynamic view of how work systems change over time through iterations involving planned change and emergent (unplanned) change. The evolution occurs through a combination of defined projects and incremental changes resulting from adaptions, making do whit whatever is available, and creating workarounds to bypass obstacles [26].

3. Method

This is an interpretive study of the closed-loop medication management process at Kalnes hospital, which is owned by the Southern and Eastern Norway Regional Health Authority. Kalnes hospital was opened in 2015 and it serves a population of approximately 300,000.

Data was collected in May 2018 by the first author, and includes observations for three days, semi-structured interviews and documents analysis. Seven healthcare workers were interviewed: three nurses from three different units, two physicians from two different units and two pharmacists from the hospital pharmacy. Medication management were observed at three different units, this encompassed prescribing medication, ordering medication, managing the store at the unit, dispensing and administering medication to patients. Observations were also conducted at the compounding unit at the hospital pharmacy while repacking drugs. Documents like reports, plans and standard operational procedures regarding medication management and CLMM were analysed.

The findings from the data collection has been presented to various stakeholders at different fora: The Health Platform, a program in central Norway that is responsible for procuring and implementing a new, common EHR for the whole health region; The Norwegian association of hospital pharmacists working with medication management; a seminar titled, "Medication Management and the Digital Revolution"; and to employees at the Northern Norway Pharmacy Trust.

The analysis used a hermeneutic approach in which the socio-technical configurations and quality aspects were understood based on the meanings of their parts and their relationships [27], [28]. Interpretation of details affects the interpretation of the entire phenomenon. The systematic interpretation gives a deeper understanding of the whole. Information from the first interviews and observations were used as foundations for the subsequent ones. Additionally, feedback from the presentations of the findings amplified some of the results, thus making some assumptions clearer and other weaker. For instance, feedback from the presentation to the Health Platform made it clearer that the focus on quality of the results should be emphasised. In this way, feedback from practice contributed to the analysis of the findings.

4. Background

CLMM is key to the Southern and Eastern Norway Regional Health Authority's strategic plan for quality and patient safety for 2016–2020. The aim of CLMM was to ensure that the right patient receives the right drug of the right dose at the right time by the right route, and reduce the number of errors and abbreviations in medication management. An eMMS able to realize CLMM and the capability of tracing the steps in the medication cycle are considered a basic preconditions [29]. Related to this, the Kalnes hospital implemented three digital systems aimed at establishing CLMM [30]. First, an eMMS, second, a stock-keeping system at the wards, and third, a chemotherapy management (cancer medication) system. These systems were supposed to be used in combination with the hospital's current HER. The EHR was also crucial in the medication management process because it communicates with digital systems outside the hospital; i.e., drug list from general practitioners and nursing homes were exchanged via the EHR. In addition, the reasons and explanations for changes in medication were documented in the EHR. This implied that four different digital systems were involved in realizing CLMM. Kalnes hospital's goal was to realize CLMM in every ward. In a report to the board in October 2018 [31], it was stated that CLMM had been implemented as planned at all somatic wards, with specialised wards and psychiatric wards awaiting implementation.

5. Results

We present data from three different wards at the hospital: one surgical ward and two regular wards. The medication loop consists of several steps. It starts when the physician prescribes drugs to a patient. This is followed by ordering and delivery from the pharmacy. Then, the nurses dispense the medication before it is administered to the patient. An important step in the loop is observing the patient and evaluating effects and side effects.

5.1. Single doses and bar-code on each dose

Given that very few drugs from the medical industry have barcodes on single units, the Southern and Eastern Norway Regional Health Authority decided that the hospital pharmacies in the region should break down medications into single doses and barcode each dose. The hospital pharmacy at Kalnes had a unit for compounding drugs that included equipment for repacking medications into single doses with barcodes on each dose.

The demand for medications that needed to be repacked was higher than the capacity of the pharmacy; hence, the pharmacy had to decide which to prioritize. One of the pharmacy's challenges regarding closed loop medication was according to one of the pharmacists, *"To satisfy the demand for repacking."* The extent of the demands from the wards at the hospital was essential for deciding what to repack. Other factors considered were the manual work required in the process. For instance, some tablets or capsules were in blister wrappings, and removing these protection shortens the shelf-life considerably. Therefore, pharmacy technicians had to use scissors to cut around each tablet to retain the blister, while still ensuring that each tablet was not too big to be placed in the automated tablet packaging system. Another consideration was the ability to store the repacked medication at the pharmacy. The new containers were big, and the pharmacy had a small storage space. The pharmacy had invested in semi-automated tablet packaging machines; however, the process still included several manual steps. Pharmacies are subjects to strict authority regulations on medication preparations, and the demand for double-checking and documentation combined with the manual steps in the repacking process requires major resources. During the data collection, the issue regarding the correct use of resources revealed that both pharmacists and pharmacy technicians could contribute to safe medication management at the wards.

"The Pharmacy has a deal with the Pulmonary ward to dispense the medication. The task is performed by trained pharmacy technicians."(pharmacist)

The same pharmacist suggested that it was better to use a pharmacy technician to dispense medication compared to a nurse because they were less labour expensive, and this would also save time and allow the nurses to attend other tasks.

5.2. Dispensing medication

The physicians produced prescriptions of medication in the eMMS. The nurses used the system to document the dispensing and the administration of the medication. The dispensing was performed in eight-square meters rooms in which the drugs were stored (see Figure 1a). Each storeroom was used by three wards for medication preparation. Several of the nurses complained that the rooms were too small. The wards had big trolleys with one drawer for each patient. The drawer was labelled with the patient's name and birth date. Each drawer was divided in one compartment for morning medication, one for lunchtime medication, etc. Figures 1b and c show the trolley and a drawer.

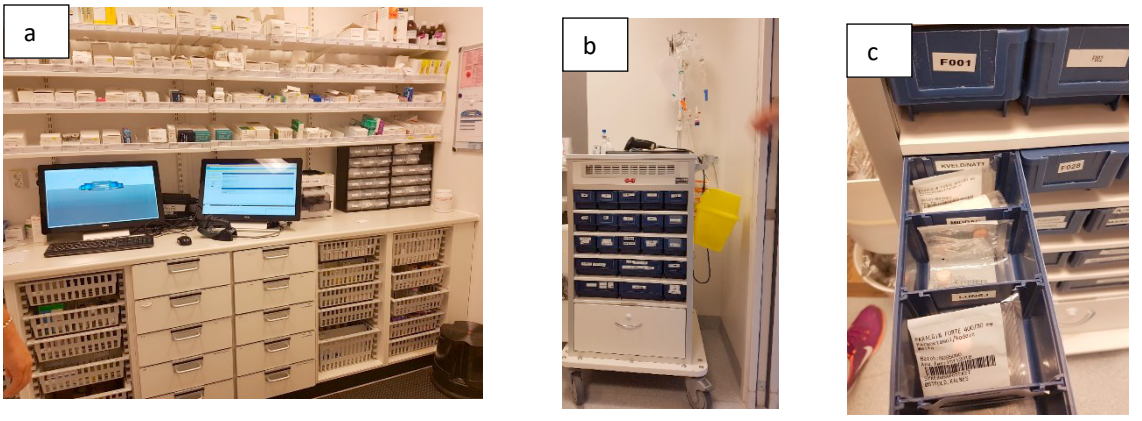

Figure 1. (a) Medication storeroom, (b) The trolley, and (c) A drawer from the trolley.

The dispensing process involved scanning the drug out of the storage in the ordering system—to reduce the

inventory count— and scanning the drug in the eMMS to document that it was the correct drug that was being selected. Hence, the nurses needed two computers, one for the eMMS and one for the ordering system, when they worked with the medications (Figure 1a). In addition, the cursor on the screen needed to be in the correct field, as displayed in the picture, for eMMS to receive the scanning. The nurses had to use the mouse to move the cursor to the correct field prior to each scanning or optionally tap the screen, if it was a touch screen. Prior to the scanning of each drug, they needed to scan the patient`s nametag on the drawer to document that the drug was being prepared for the right patient. The nurses complained that they did a lot of scanning. The scanning was time consuming, especially due to the latency in eMMS during the scanning. Slow response in the digital systems led to delays and irritations. Examples of other technical the user often experienced, were trouble logging into the systems, printers for the labels that was not connected to the system or otherwise, did not function as intended.

To scan a drug, it must have a barcode on each single unit. Even if the pharmacy repacked tablets, the nurses encountered, on several occasions, medications that lacked barcodes. During the observation, we estimated that approximately one-fifth of the tablets and capsules lacked a barcode. There were different reasons for this. The hospital had allowed the use of multidose dispensed drugs from primary care during hospital stay. Thus, the nurses had to check whether the multidose dispensed drugs correlated with the prescriptions in the eMMS. The barcode on the multidose dispensed drugs was not the same format as rendered in the eMMS. Hence, those multidose barcodes could not be scanned. The medication in the multidose had to be approved manually by checking off each drug against the drug list in the eMMS. For one patient, the prescribed dose in the eMMS was different from the multidose. The general rule was that the eMMS version was correct. In this particular case, the nurse chose to look for information about the dose in the EHR. As the information in the EHR was in free text, she had to read several notes to find the information she was looking for. Eventually, she discovered a note from a physician that the dose was increased, and she had to obtain an additional tablet from the store, which she placed into the patient's drawer.

In one case, a patient had a prescription for a drug which the ward lacked the correct dose in store; they had the same drug in half the dose. The nurse prepared two tablets in half dose for the patient, but a limitation in the system allowed her to scan only once. Therefore, she manually had to document that she had prepared two tablets in half the dose each. The challenge was that the process included no electronic check, only a manually documentation.

Another patient had the opposite issue. The ward stored the drug only in its double-dose form. The nurse opened the blister wrapped around the tablet to see if it had a line that indicated that it was safe to divide the tablet. This particular tablet had no mark or line. Therefore, she looked up the drug online and learned that the tablet should be swallowed whole. Her first solution was to borrow the drug from another ward. She used the ordering system to check which ward had it in store. Unfortunately, no other ward had it in store. She then proceeded to order the drug from the pharmacy, but then noticed that the drug was already ordered by another nurse and would arrive at the ward later.

One patient used a medication that was a combination of two active ingredients. This combination was not in store at the ward. Hence, the nurse dispensed two tablets with the active ingredients separately. As in the previous examples, she manually had to change the documentation in the eMMS. Some drugs were kept in containers with multiple doses in each container. For instance, oral suspensions (mixtures), inhalers for asthma or COPD, insulin pens, eye drops and vials with substances for injections or infusions. Additionally, several tablets and capsules were not individually wrapped, but stored in containers. Others were individually wrapped, but the wrappings lacked a barcode.

For some of the examples mentioned above, the nurse first scanned the container or the package containing the drug. Next, she placed the tablet in a small zip-lock bag, and then printed the barcode for the prepared tablet(s) from the eMMS, which she attached to the zip-lock bag. During the dispensing of the medication, the nurse had two options on how to document this in the eMMS. They could scan the barcode or they could manually choose the drug in the eMMS, before clicking on a button for dispensing. Thereafter, it was not possible to see in the eMMS which option was used. This applied to all the manual documentation of changes by the nurses—it was not possible to know whether the dispensing was verified manually or electronically. In some instances of missing barcodes, the nurses found solutions that "tricked the system". For instance, if the tablets were in a container and not individually wrapped, they kept the last one of an equivalent tablet in a single-dose unit with a barcode. The barcode on this was scanned, but a tablet from the multiple-dose container was dispensed.

A similar situation occurred for antibiotics. Antibiotics were stored in another room across the hall. The reason was that the drugs occupied big volumes, and there was no room for that in the medication storeroom. Previously, there was a list on the wall in the medication storeroom with the different antibiotics. Beside the names was the

barcode for each drug. This allowed the barcodes to be scanned during the preparation in the medication storeroom, and the antibiotics would then be collected from the other room after completing the drug preparation for all patients. The purpose of scanning a barcode is to ensure that the correct drug is selected. By scanning a barcode not connected to the selected drug undermined the purpose and quality control embedded in the scanning.

Accordingly, dispensing to achieve CLMM was time consuming and demanded intensive resources. Due to this, some wards chose not to practice CLMM on days with reduced personnel or when they had several demanding patients. Other wards chose to only practice CLMM during the day shift. Those wards skipped the scanning. Again, as mentioned previously, it was not possible to distinguish in the eMMS whether the drugs were scanned or not. Some of the nurses doubted that the effort was worth the gain, as one nurse said *"closed loop medication takes a lot of extra time. Time and space." (nurse 1).* She also questioned whether the extra time spent was worth it regarding patient safety. Similarly, another nurse was asked whether she was more confident that the right patient received the right medication with the current CLMM than she was before the closed loop was implemented, to which she responded, "*I was sure about that previously as well."(nurse 2)*

5.3. Administering medication

Some drugs needed to be prepared directly before use because of short expire time. An example of such drugs were antibiotics for infusion. At Kalnes Hospital, it was decided that the preparing of infusions should be performed at the patient's bedside. It is important that drugs that are infused into patients are clean and without microbes or other contaminations. Additionally, for antibiotics, it is important to avoid exposure of the active substance to the environment or to the nurses. This is mainly to prevent development of antibiotic resistance. To ensure this, the hospital used reconstitution devices that connected the vial and bag with salt water without activation, allowing reconstitution at the point of administration by the breaking of a valve. Reconstitution in this case meant that the active drug ingredient, which was a powder, had to be dissolve in a liquid (reconstituted) before it was administered to the patient. The challenge occurred when those "closed systems" were not available. In such cases, preparation was performed with a syringe and cannula, dissolving the powder in a solvent and diluting the solvent, of which had to be done at the patient's bedside in circumstances not designed for such tasks. The nurses had no space for the work; hence, the drugs and the equipment were placed on the keyboard of the nurse's laptop. The environments were not clean, and the nurses did not have all equipment needed, for instance, disinfectants or gloves.

Other injections, for instance insulin, did not have a barcode on each dose and was dispensed and administered without the barcode controls. There were no other kinds of control or checks to verify that the dose and drug were correct. When administering the tablets that were previously dispensed in the shelves in the trolley, the nurses scanned the barcode on the patient's wrist and then each tablet. When asked, some of the nurses said that they did not think that the medication management was safer for the patients after the implementation of the processes that was supposed to close the medication loop. One reason that was mentioned was that the focus shifted from the patient to the technical equipment as emphasized by one of the nurses: *"We have focused on administering the drugs, not on observing the patient." (Nurse 2)*

The hospital had decided that not all dosage forms needed to be scanned. This includes, for instance, inhalations, insulin and other types of drugs that are injected. The reason was that the features of the drugs made it difficult to have a barcode on the specific dose. One nurse mentioned this as a reason why she doubted that the medication management was safer for the patients after the implementation of CLMM. The main challenge with this practice is that compared to oral drugs in tablet forms, mistakes made with injections are often more critical for the patient. Hence, the scanning was primarily focused on the drugs with the lowest risk.

As for dispensing, the scanning to close the loop during administration was time consuming. Accordingly, some wards chose not to practice CLMM at all times. Instead of scanning, the nurses manually clicked for administered drugs in the eMMS. It was not possible to distinguish in the eMMS whether the drugs were scanned or manually documented.

"The system is very slow. Hence, we don't use it much when we administer medication. You will never finish." (Nurse 3)

Another consequence along the same line, regarding closed loop, was that the nurses were committed to the technical task such as reading the digital systems and scanning medication and patients, and hence the attention on the patients was decreased. Whether the patient had effect or side effects or other issues with the medication was not the main focus and tended to be ignored. Several of the informants mentioned this as a disadvantage after

introducing the new practice.

> *"Previously (before closed loop medication), you might go to the patient with the medication and tell what is what. Then check if the patient agrees and then administer it. Now, we experience that we concentrate more on the computer screen and are more concerned with making that work than to communicate with the patient." (nurse 1)*

The nurse was asked whether she could potentially lose important information regarding side effects etc. because of this: *"Yes, and maybe the patient don't feel seen because we keep our nose in the computer screen all the time."(nurse 1)*

6. Discussion

The main goal of a closed loop is higher quality and patient safety. Spending resources to achieve this goal is both expected and accepted. The key challenge is to consider the strategies for achieving this goal and to evaluate whether the quality gains are worth the costs.

6.1. CLM – a sociotechnical commitment achieved in practice

In the literature CLMM is generally portrayed as a seamless digitally-based process that ensures top quality in medication management for patients [10], [12], [13]. Each step in the medication cycle is duly documented and traceable. However, although it is easy to agree on the intention and ambition implicated in CLMM, our study illustrates that intentions and real practice are two different things. A key assumption is that implementing an eMMS will offer CLMM capabilities per se. This is too simplistic. An eMMS must operate alongside an existing installed base [22], [32], such as the hospital's EHR and different equipment including trolleys, scanners, barcode printers and plastic bags. This interplay also includes other digital systems needed to support the CLMM, i.e., stock-keeping systems and chemotherapy systems. In sum, these systems and artefacts represent a heterogenous information infrastructure that may enable CLMM [16]. Nonetheless, although this portfolio may enable CLMM, each of the systems also have important functions in their own right, thus making it very hard for the alternative, i.e., replacing all the systems with one system aimed at digitalizing support for CLMM.

Similarly, assuming that users (health care professionals) using the eMMS will obtain CLMM is far from sufficient. We should rather look at it through the lens of work system theory, where health care professionals perform work using information, several IT-systems, trolleys, scanners, plastic bags etc. to produce medication management services for the patients [26].

As we have elaborated in our theory sections, what needs to be included to obtain CLMM is vague, and there are different meanings associated with CLMM. Rather than committing to one of them, we take a different angle where we conceptualize CLMM as closely intertwined with practice. In examining CLMM in practice, a complex and messy picture emerges, which is far from the glossy images frequently depictured in the literature. In this regard, one cannot be guaranteed a CLMM as an effect of implementing an eMMS. It implies a lot of *work* by health personnel at various steps in the loop. Thus, CLMM is not an entity that exists apart from practice; it is rather engaged with and performed by the health personnel in their daily work. Similarly, as an information infrastructure, CLMM becomes an integral part of practice [22]. Along these lines, we argue that CLMM should rather be considered a socio-technical commitment for the health personnel in their daily efforts to obtain good quality in medication management.

6.2. The two-side coin of workaround

In our study, it is hard to ignore that it was highly time consuming to achieve CLMM. For the nurses, the scanning process when dispensing and administering the drugs was particularly cumbersome. The pharmacy experienced similar burden; given very few drugs bought from the medical industry had barcode on each single unit, the pharmacy had to break down medications into single doses and barcode each dose. However, the pharmacy was not capable to repack all medication the hospital needed; hence, approximately a fifth of all tablets and capsules lacked barcodes. To close the loop for drugs without barcodes, the nurses had to perform extra work. As our results show, to dispense a medication is a process with several exceptions from the planned process. For instance, when

the ward lacked the dose or the combination in accordance with the patient's prescription, the nurses had to engage in a workaround [17], [19] to ensure that the patient received their medication; for instance, by dispensing two 10 mg tablets instead of one 20 mg tablet, or dispensing two separate ingredients instead of the combination that was prescribed.

Although the workaround referred to above was crucial to ensure that the patients received their medication and, thus, to realize CLMM, other kinds of workaround could outright jeopardize patient safety; for instance when a barcode on another tablet than the one selected was scanned or when the barcode on the wall was scanned. Unfortunately, the bad working conditions made things worse. The big trolleys in the small medication storerooms caused the nurses to constantly interrupt each other during the process of scanning and preparing medication for the patients. In the end, the system had no way of showing whether the documentation in the medication management was made by scanning or by manually updating the system. This implies that, in retrospect, it was not possible to know if the medication loop had been closed or not. There were also patient safety issues when preparing antibiotic infusions at the patient's bedside because the medication was not protected from contaminations from the environment and the nurse was not protected from exposure to the antibiotics.

Accordingly, we argue that there are two sides to workarounds. On the one hand, some workaround is a precondition for successfully implementing a new technology [17], but on the other, too much workaround and workaround too far from the prescribed routines may result in unexpected negative side-effects for the patient as well as for the organization. A major problem is when a workaround that potentially compromises patient safety, over time turns into a permanent routine [18], [20] and thus, become institutionalized. It is therefore crucial that the work practices—and workaround—associated with new technology is visible to all stakeholders at points where it is possible to evaluate its consequences. The WST perspective emphasize that CLMM evolve not only through planned changes, but also through incremental changes resulting from adaptions and creating workarounds to bypass obstacles [26].

6.3. CLMM – a false sense of patient safety?

In principle, introducing a CLMM to secure the administration of the right medication to the right patient by scanning each single dose of the drug against the patient's barcode is a quality assurance of the medication management process. However, as our case shows, maintaining a complete CLMM is extremely resource-demanding, and therefore it should come as no surprise that Kalnes hospital's version of a CLMM, only included some medications and was not performed at all times. The closed loop in Kalnes was limited to ensuring that the medication prescribed by the physician was administered to the right patient at the right time. To assure optimal medication, it is equally important that the drug prescribed is the best option, the dose is optimal, interactions between drugs are accounted for, side effects are detected, and the effect is assessed. CLMM at Kalnes did not include any of these elements, neither did it ensure patient involvement, such as co-decision in selecting a drug or education on the proper use of the medication. Further, the medication included in CLMM was linked to tablets and capsules, whereas other dosage forms, including, for instance, injections and some infusions, were not included. Injections and infusions often have higher risks of harm or adverse effects for the patients compared to oral dosage forms such as tablets and capsules. The nurses spent a lot of time and focused on closing the loop, whereas medications not included in the loop received less attention. For instance, the nurses did not double-check most of the injections and infusions administered to the patients despite the fact that the Norwegian medication management regulations recommend double-checking such dosage forms [33].

We do not intend to engage in a dispute on whether Kalnes have implemented CLMM or not. We rather note that, given the amount of work involved in maintaining a CLMM, it makes sense to carefully consider what medication should be included in the CLMM and what medication could be excluded in the process. Drugs with high risk for the patients should be included, but to define a high-risk drug is not an easy task. Such definition may depend on the route of administration of the medication, for instance, oral versus intravenous. There might also be drugs with similar names that could be easily swapped. Other kinds of consideration may be whether the medication included has severe adverse effects or a narrow dosing interval. The patient's conditions may also be an issue, i.e., children, older people or critically ill patients.

A problem related to CLMM is that after its implementation, there is an overall belief that this is achieved for all medications. However, this study shows that even if the quality in parts of the medication management process is increased, other important parts of the process may receive less attention. This was pointed out by several of the

informants that doubted that the CLMM had led to better safety for the patients.

7. Conclusion

Due to the findings in this case, we conclude that implementing closed loop medication system will not necessarily lead to increased quality in the entire medication management process. Nevertheless, the engagement and commitment of the healthcare workers show promise for future adjustments and quality improvements. We draw the following implications: First, medical personnel need not to fixate on only technical issues, but rather aim for the main goal, which, in this case, is optimal and safe medication management. New systems should ideally support, not increase the work burden. Otherwise, the additional work must be balanced against the increased quality it aims to achieve to assess whether it is worth the cost. Second, the decision in this case to focus on tablets instead of injections and infusions points to the fact that some practices may compromise other more important practices. It is therefore crucial for hospitals implementing CLMM to have a strategy for including and excluding medications, as well as carefully assess the consequences of the decision. Third, work(around) occurring as a consequence of new digital systems must be accounted for, and potentially evaluated to avoid individual healthcare professional needing to develop routines that cements practices that may compromise safety. This is clearly a responsibility for the hospital management.

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