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Barcode medication administration technology use in hospital practice: a mixed-methods observational study of policy deviations

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► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjqs-2021-013223).

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Received 20 February 2021
Accepted 5 July 2021
Published Online First 20 July 2021

To cite: Mulac A, Mathiesen L, Taxis K, *et al*. *BMJ Qual Saf* 2021;**30**:1021–1030.

ABSTRACT

Introduction Barcode medication administration (BCMA) can, if poorly implemented, cause disrupted workflow, increased workload and cause medication errors. Further exploration is needed of the causes of BCMA policy deviations.

Objective To gain an insight into nurses' use of barcode technology during medication dispensing and administration; to record the number and type of BCMA policy deviations, and to investigate their causes.

Methods We conducted a prospective, mixed-methods study. Medication administration rounds on two hospital wards were observed using a digital tool and field notes. The SEIPS (Systems Engineering Initiative for Patient Safety) model was used to analyse the data.

Results We observed 44 nurses administering 884 medications to 213 patients. We identified BCMA policy deviations for more than half of the observations; these related to the level of tasks, organisation, technology, environment and nurses. Task-related policy deviations occurred with 140 patients (66%) during dispensing and 152 patients (71%) during administration. Organisational deviations included failure to scan 29% of medications and 20% of patient's wristbands. Policy deviations also arose due to technological factors (eg, low laptop battery, system freezing), as well as environmental factors (eg, medication room location, patient drawer size). Most deviations were caused by policies that interfere with proper and safe BCMA use and suboptimal technology design.

Conclusion Our findings indicate that adaptations of the work system are needed, particularly in relation to policies and technology, to optimise the use of BCMA by nurses during medication dispensing and administration. These adaptations should lead to enhanced patient safety, as the absolute goal with BCMA implementation.

INTRODUCTION

Barcode medication administration (BCMA) technology is a health information technology credited for preventing medication errors and promoting patient safety when used accurately.[1] BCMA technology automates the process of verification by scanning the barcode on the medication and the patient identification wristband, thus assisting the nurses in confirming the 'five rights' of medication administration: right patient, right medication, right dose, right route and right time.[2] In an effort to prevent consequences of medication administration errors to patients,[3] hospitals have strongly encouraged BCMA implementation.[4–7] The BCMA has shown to reduce medication administration errors significantly and to reduce harm from serious medication errors.[8] Previous studies have also reported an increase in patient identity verification rate after implementing BCMA.[9 10]

While BCMA has existed for over two decades, hospitals have struggled to adapt and implement it within their existing infrastructure,[5 11–15] and several studies demonstrate that the implementation process for BCMA is important for its overall success.[12 13] Studies have shown increased workload or disrupted workflow with the use of BCMA, resulting in workarounds,[7 12 14 16 17] such as carrying prescanned medications on carts.[18] These workarounds, also described as policy deviations, can lead to new errors created by the use of the technology.[7 12 18]

Although previous studies have identified workarounds and policy deviations with BCMA,[7 12 18] there has been limited research to disclose why deviations occur and the impact of the surrounding context to their occurrence. One systematic review that evaluated the impact of BCMA technology to patient safety concluded that human factors and technical issues are standing in way of achieving intended scanning rates and patient safety benefits.[1] Another systematic review came to a similar conclusion and highlighted the importance of analysing whether deviations that are outside the five types of medication errors can have important

implications to patient safety.[19] The purpose of this study, therefore, was to investigate nurses' interaction with the technology and identify policy deviations as potential unsafe practices using a human factors approach.[20] More specifically, the study aimed to (1) gain an in-depth understanding of how nurses actually use the BCMA during medication rounds, (2) to record the number and types of BCMA policy deviations during medication dispensing and administration, and (3) to investigate probable causes of policy deviations in relation to the socio-technical factors of the working environment.

METHODS

Overview

We used a concurrent triangulated, mixed-methods design comprising structured observation (quantitative data) and field notes and nurses' comments (qualitative data) of BCMA use at two medical wards at a 700-bed hospital in Norway. Structured observation, involving a digital observational tool, was used to quantify policy deviations. Field notes and nurses' comments contextualised the quantitative data, provided explanations and sometimes cued the causes to policy deviations.

Theoretical framework

We used the SEIPS model (Systems Engineering Initiative for Patient Safety)[16 20] to provide the theoretical underpinning for this study. This model explores interactions between humans, the technology they use and the environment in which they work, and has been successfully applied in the field of medication administration technologies,[16] as well as across healthcare.[20] In our study, we applied the SEIPS model to categorise the integrated qualitative and quantitative data according to the five elements of the SEIPS model[20]: (1) tasks, (2) organisational factors, (3) technology, (4) physical environment, and (5) individuals.

Setting

The study hospital was the first to introduce eMAR (electronic Medication Administration Record) and BCMA technology in Norway. The technology was implemented over a 3-year period, from 2017 to 2019. The studied eMAR and BCMA were a part of Metavision, iMDsoft. In addition to the digitalised medication records, the system comprised barcode scanners, patient identification (ID) wristbands, single-dose medication units, and scanning during dispensing and administration. The hospital used a decentralised ward-based dispensing system. The description of the delivery, dispensing and administration process with respective policy descriptions is illustrated in figure 1. Data were collected on two wards: a cardiac medical ward and a geriatric intensive care ward. Other ward characteristics and dates of observation are summarised in online supplemental appendix 1.

Definitions

We defined a policy deviation as the act of dispensing or administering a medicine that was not in accordance with the hospital policy. *Task-related deviations* were failures with tasks involving use of barcode scanning during dispensing and administration. Organisational policy deviations included violations of hospital medication management policies, for example dispensing the wrong dose of the medication in the patient drawer placed in the computer on wheels

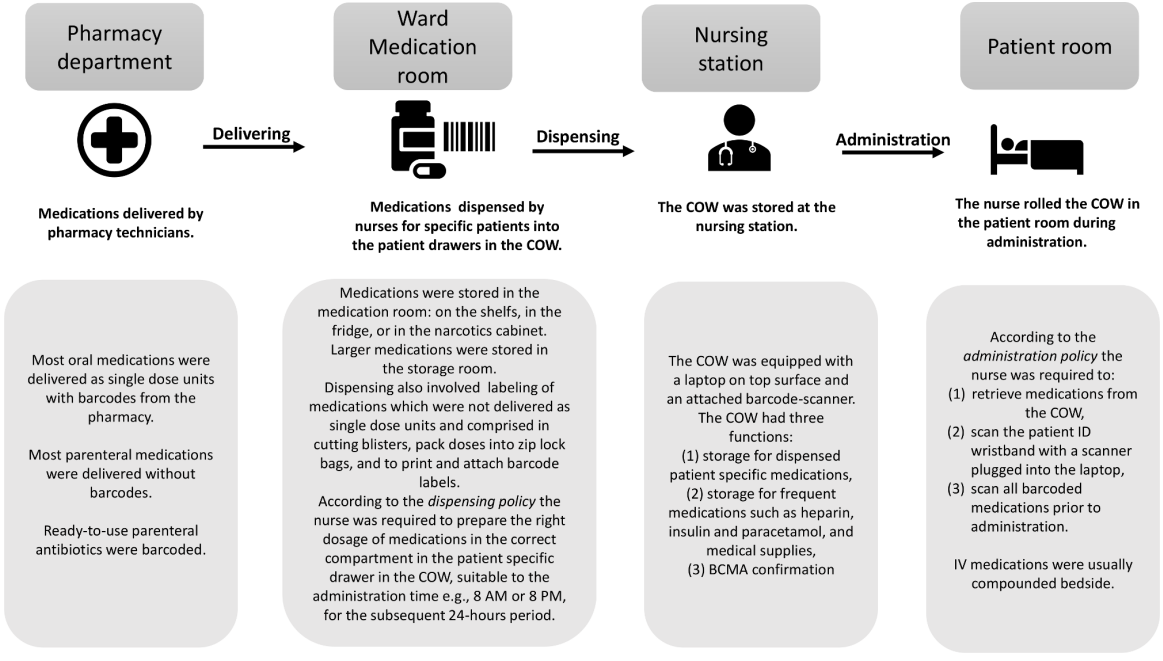

Figure 1 Description of the dispensing and administration process. BCMA,barcode medication administration; COW, computer on wheels.

(COW). Technology-related factors included problems with the technological equipment (hardware and software) associated with the BCMA. Environmental factors were elements of the physical environment that affected the BCMA. Nurse-related factors were related to the practice or comments of individuals.

Data collection

One registered pharmacist and one fifth-year pharmacy student observed medication administration rounds between October 2019 and January 2020. The observers contacted the assigned nurse on the respective ward prior to the medication round, explained the purpose of the study and obtained written consent. Upon entering the patient room, the nurse informed the patient briefly about the presence of the observer and the purpose of the study. To minimise observation bias,[21] the observers remained silent during observation. No patient-identifiable data were recorded. The observer alerted the nurse if they became aware of a medication error with the potential to cause patient harm.

We used a digital observational tool (described later) to record quantitative data and checked for consistency by the research team. Data were collected using handheld tablets and directly sent to a secured server for storage. After completing the structured observations of the medication rounds, the observers documented additional qualitative field notes of the medication safety environment and any comments made by the nurse.

Data collection stopped when saturation was achieved, and the research team members evaluated that additional data would not lead to new information.[22] The observers periodically met with the research team to review observation data for this determination.

Development and piloting of the data collection tool

A digital observational tool, using secure web-based data survey software,[23] was developed to collect data during medication administration. The tool was piloted for 7 days, by two observers, who observed the administration of medications to 30 patients on two medical wards. While the pilot data were not included in the main study, they were discussed by our inter-professional research team, and each question in the observational tool was evaluated for relevance to the research question and consistency with current evidence. We developed separate data collection tools for oral and parenteral medications because the differences in their administration processes (online supplemental appendices 2 and 3). The 28 questions in the oral and parenteral observational tool (14 questions in each) were aligned with the workflow described in the hospital policies and quantified data on the following:

- The total number of medications; scannable and scanned medications; number of scanned patient ID wristbands.
- Policy deviations with dispensing, labelling, storage or scanning.
- Technological problems with equipment or software.
- The storage of inpatients' own medications.
- A free-text option in the tool was available to register the observers' comments.

Analysis

Quantitative data from both observational tools were merged; any string data were converted to numeric values. Scanning rates and frequency of policy deviations were analysed using descriptive statistics with IBM SPSS V.25. Qualitative data were analysed with inductive thematic analysis[24] through an iterative process. Two researchers coded the data assigning utterances to themes which were developed as they emerged from the data. The researchers discussed the manner in which the data fitted in the themes to reach joint consensus. Following the separate analysis of quantitative and qualitative data, we integrated the two data sets using a triangulated approach.[25 26] Key findings from both data sets were identified and complimentary findings were compared to enhance validity and provide a deeper understanding of policy deviations and their causes. The integrated findings were then categorised according to the five elements of the SEIPS model.[20]

RESULTS

A total of 44 nurses were observed while preparing and administering medications; 29 during the morning and 15 during the evening medication rounds. We observed the administration of 884 medications (mean per patient, 4.2; range, 0 to 14) to 213 patients (table 1). In total, 133 patients (62%) received oral medications only, 59 patients (28%) received both oral and parenteral, while 21 patients (10%) received only parenteral medications.

Task-related policy deviations

Data source: observational tool

We registered how nurses used BCMA during dispensing and administration. Task-related policy deviations affected 140 patients (66%) during medication dispensing and 152 patients (71%) during medication administration, illustrated in figure 2. During administration, we identified three variations in nurses' BCMA use which resulted in deviations: nurses did not use BCMA; nurses partially used BCMA; nurses used BCMA correctly, but deviations still occurred.

Organisational policy deviations

Data source: observational tool, field notes and nurses' comments

Organisational deviations were deviations from the medication management policies. In terms of medication administration deviations, these arose with not scanning 29% medications and 20% patient ID wristband (table 1).

Table 1 Characteristics of the observed barcode medication administration

Characteristics	Ward 1	Ward 2	Total (%)
Observation duration	14 hours 35 min	17 hours 48 min	32 hours 23 min
Number of observed nurses	22 (21 female; 1 male)	22 female	44
Number of observed medication rounds	18 (12 at 8:00; 6 at 20:00)	20 (14 at 8:00; 6 at 20:00)	38
Total number of observed patients	94	119	213 (100%)
Number of patients with scanned wristband	85	85	170 (80%)
Total number of medications	447	437	884 (100%)
Number of barcoded medications	373	315	688 (78%)
Number of scanned medications	319	306	625 (71%)

We identified 10 types of policy deviations during the dispensing process. The most frequent were medication not dispensed (n=80 patients), barcode label missing (n=70 patients) and wrong dose dispensed (n=30 patients). Dispensing deviations and their connection to potential medication errors are listed in table 2. All data in table 2 are presented as deviations, although three of these deviations also classify as actual medication errors including wrong medication dispensed, wrong dose dispensed, and medication not dispensed and not administered which is a medication omission. These deviations in the COW were often revealed after the nurse had entered the patient room and resulted in a prolonged and frequently interrupted administration, which led to medication omission for 25 patients. For 11 patients, scanning in the eMAR prevented administration of the wrongly dispensed medication. The observer intervened on one occasion when a nurse dispensed a wrong (look-alike) medication from the medication room and intended to give to the patient.

We also observed deviations from the storage of patients' own medication (home-brought). According to policy, patients' own medication should be stored in the COW or the medication room. We registered a 96% deviation rate from this policy (table 2). Patients' own medications were not integrated in the BCMA and were not barcoded or scanned.

Technology-related factors

Data source: observational tool and field notes

Technology-related factors were registered with the observational tool and deviations were found in 38 observations (18%). These included low

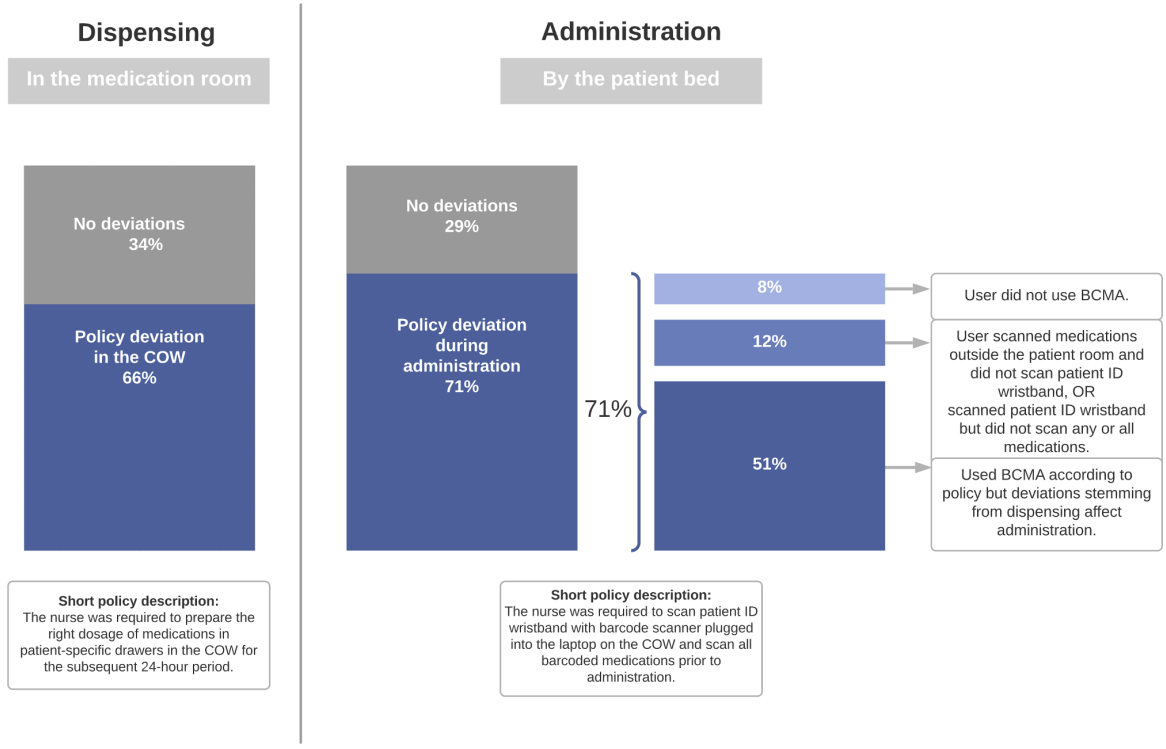

Figure 2 Task-related policy deviations with barcode medication administration. BCMA, barcode medication administration; COW, computer on wheels.

Table 2 Organisational policy deviations with barcode medication administration and their connection to potential medication errors

Types of policy deviations*	N	Examples and descriptions	Potential medication errors
Medication not dispensed; obtained and given during observation Medication not dispensed; not given during observation†	55 25	Nurse did not check for omission of dispensing before administration round start even though some medications (eg, parenteral injectables) were not expected to be found in the COW at all	Omission
Barcode label missing	70	Dispensed tablets without a barcode label, or without primary packaging	Wrong medication Wrong dose
Wrong dose dispensed†	30	Dispensed whole blister pack instead of one tablet (correct dose)	Wrong dose
Scanning failure	26	Barcode on the medication was not readable for the scanner	Wrong medication Wrong dose Wrong route
Barcode label not attached	13	Barcode label was in the patient drawer but not attached to the medication Nurses stored expired labels for future administrations to save time from printing new labels	Wrong medication
Wrong medication dispensed†	11	Dispensed extended-release tablet instead of tablet Dispensed sound-alike medication, for example, Lescol instead of Losec Dispensed 2 g Cloxacillin intravenous bag from the storage room instead of 1 g Errors discovered by scanning in eMAR	Wrong medication
COW deviations due to recent changes in the eMAR	7	Antithrombotic medication was dispensed in the patient drawer, nurse removed it during administration due to the patient being scheduled for surgery that day	Contraindication Wrong drug Wrong route
Medication placed in the wrong compartment in the drawer	5	During dispensing, medication prescribed for morning administration was placed in the compartment in the patient drawer assigned for evening administration	Wrong medication Omission or wrong time
Wrong room number on patient drawer	3	The patient changed the room, but the room number on the patient drawer was not changed	Wrong patient
Wrong label attached	1	Attached 'metoprolol' label on a generic substitute Bloxazoc (metoprolol) unit dose. Revealed after failure with scanning the label	Wrong medication Wrong dose
Patients' own medication stored in the patient room	24	We observed deviation of this policy for 24 of total 25 patients' own medications (96%)	Wrong dose Wrong medication

*The number of deviations refers to one deviation of the same type per patient even if more deviations of same type exist with one patient, for example, if one patient had wrong dose dispensed for two medications, this was counted as one deviation.
†Deviations which also classify as actual medication errors.
COW, computer on wheels; eMAR, electronic Medication Administration Record.

laptop battery in 28 observations (13%), system freezing in seven observations (3%), malfunctioning barcode scanner in two observations and the barcode scanner was unavailable for administration in one observation (online supplemental appendix 4). Software problems included slow response and the need for multiple clicking after scanning each medication. Nurses used the laptop mousepad to navigate the eMAR, and this extensive clicking was perceived by the nurses as frustrating. The size of the COW was deemed to slow the administration process and lead to deviations.

Environmental factors

Data source: observational tool, field notes and nurses' comments

Medication rooms were located some distance from the nursing stations and patient rooms. The nurses ran back and forth to the medication room multiple times during an administration round to rectify deviations in the COW. Other disruptive environmental factors affecting the BCMA workflow were the fact that the patient drawers were too small and could not contain all the patient medications. We also observed that the work surface of the COWs and at the nursing stations were often untidy and contained single-dose units from past administrations or falsely dispensed medications.

Nurse-related factors

Data source: observational tool, field notes and nurses' comments

Several nurses admitted that they did not use the barcode scanning equipment on a daily basis. If the ward was particularly busy, nurses tended to discard BCMA because they perceived it slowed down the medication administration. However, nurses who used BCMA regularly valued the automated medication verification because it confirmed that the right patient would receive the right medication.

Probable causes of BCMA policy deviations

The probable causes of BCMA deviations and their data sources are listed in table 3. Under task-related deviations, the failure to scan medications during administration occured because scanning was discarded during dispensing; a non-streamlined workflow during administration was caused by a

Table 3 Probable causes to barcode medication administration policy deviations according to the SEIPS categories

Probable cause	Example from observation/description	Data source
Tasks related		
Scanning discarded during dispensing	Medications which were dispensed without scanning in the eMAR failed to scan during administration	Observational tool
Workflow not adopted to required tasks during administration	Nurse makes multiple runs back and forth to the medication room to retrieve not dispensed medications which interrupts the workflow and may affect patient safety	Observational tool Nurses' comments
Suboptimal task performance	Voluminous medications (such as infusion bags, inhalers, eye drops) are routinely not scanned during dispensing because they are retrieved during administration	Observational tool Nurses' comments
Organisational		
Dispensing practices not adopted to nurse's workload, resulted in normalising deviations	Manual labelling of medications during dispensing on ward was challenging to carry out without workarounds	Observational tool
Non-standardised dispensing process resulted in frequent deviations	Medication not barcode labelled; scanning failure; wrong dose dispensed; wrong medication dispensed; medication not dispensed; wrong label attached	Observational tool
Unclear procedures or task not assigned	Varying practice between the wards on updating the dispensed medications in the COW due to recent changes in the eMAR	Observational tool Nurses' comments Field notes
Poor routines/not followed routines for changing the room number on patient drawer	Room number on patient drawer was another patient's room number (Each patient drawer was labelled with room number and this was the first step in identifying the patient's medications)	Observational tool
Unaware of hospital policies	Patient's own medications stored in the patient room. Due to policy, patients' own medication should be stored in the COW or the medication room	Observational tool
Technology		
Poor charging routines or non-compliance with routine	The laptop battery was low either at the start or during administration	Observational tool
eMAR usability issues	Slow eMAR response and need for multiple clicking after scanning each medication	Field notes
The scanners were not wireless and limited the patient ID scanning	Nurse scanned medications prior to entering the patient room and administered medications while the COW was in the hallway, meaning that the patient ID wristband was not scanned	Field notes
Suboptimal COW design	Nurses often avoided to bring the bulky COW into the patient room when administering few or one single medication The COW design was cumbersome for the desired workflow of entering patient rooms during administration rounds The COW contained medications for all patients which combined with scanning not being used is a risk for patient safety	Field notes Nurses' comments
Environmental		
Medication room location affects task efficiency and time spent administering medications	The medication room was located far from the nursing station and most of the patient rooms. This resulted in slower administration and storage of random medications in the nursing station to avoid going back and forth to the medication room	Observational tool Field notes
Patient drawer size does not allow appropriate BCMA use	The small size patient drawer led to deviations such as not dispensing the medications because only small forms of oral medications and ampoules were dispensed in the patient drawer, whereas voluminous medications were retrieved during administration	Observational tool Field notes Nurses' comments
Non-specific medication storage policy	Random single-unit doses stored on the desk in the nursing station or on the COWs and were obtained from here in case something was missing during administration. Unsafe practice as the single doses are easy to mix up when stored randomly on the COW during administration	Field notes
Nurse related		
Non-standardised dispensing allows variations	Variations in performance between nurses and inconsistency in dispensing medications for the same nurse	Observational tool Field notes Nurses' comments
BCMA slower than manual verification—leading to user dissatisfaction	Nurse did not use the BCMA at all during the whole medication round Nurse admitted to not using the BCMA on regular basis but used it during observation period	Observational tool Field notes Nurses' comments

BCMA, barcode medication administration; COW, computer on wheels; eMAR, electronic Medication Administration Record.

mismatch with the tasks required during administration. Causes for organisational deviations were associated with unclear or poorly described policies, health professionals unaware of policies or the policy was incompatible with workflow. Even when the policy was clear and excluding, deviations occurred; for example, the policy stated that only the prescribed dose should be dispensed, however occasionally whole tablet blisters were dispensed in the COW.

Probable causes for deviations associated with technology were poor or unclear charging routines, the scanner was not mobile but attached to the laptop, and software usability issues. In addition, the design of the COW, including its large/bulky size, sometimes prevented nurses from scanning the patient ID wristband at the bedside. Furthermore, the undersized patient drawer led to dispensing omission because there was insufficient capacity to store all the medicines. Nurse-related deviations were caused by the slow BCMA process, which led to refraining from scanning or to skip the technology use. These factors all conflicted with patient safety during medication dispensing and administration.

DISCUSSION

We observed policy deviations which affected 6 of 10 patients during dispensing and 7 of 10 patients during medication administration. The causes to policy deviations were related to a complex dispensing process, slow or cumbersome BCMA procedure, suboptimal technology design and non-specific policy description. Working with suboptimal solutions in a busy environment, it was hard for the nurses not to deviate from policies, which explains why deviations were normalised in practice.

Despite these imperfections, our findings suggest that when the scanning of medications and ID wristbands was used, it offered benefits to patient safety by preventing the administration of wrong dispensed medication for 5% of the patients.

The lack of standardised delivery of dispensed doses lead to several variations in how the medications were dispensed in the COW. Patterson *et al*[27] found that BCMA made it easier to anticipate others' actions and detect erroneous actions. In our study, however, it was difficult for other nurses to take for granted that the medications dispensed by a fellow nurse were correct. To compensate for the uncertainty, the nurses had to manually reconfirm doses before administering to patients. This practice undermines the purpose of BCMA.

The scanning rates in our study, that is, 71% for medications, 91% for scannable doses and 80% for patient ID wristbands, are considerably lower than the 95% standard goal for scanning medications and patients.[28] In a recent observational study of BCMA at a UK hospital, Barakat and Franklin registered scanning rates for medications of 83%, scannable doses of 95% and patient verification of 100%.[29] Although Barakat and Franklin had a smaller sample size, their study was undertaken with a similar ward-stock dispensing process and BCMA technology design to our study, which makes the rates broadly comparable.

A recent national study of medication errors in Norwegian hospitals, where BCMA was not used, found that 70% of all medication errors occurred during the medication administration stage.[3] We suggest that many of these errors, such as wrong dose, wrong patient and wrong medication during administration, could have been avoided if BCMA had been implemented. However, even if the technology is used accurately, hospitals may still fail to achieve the full benefits of BCMA to patient safety and unintended consequences may arise from technology implementation,[18] both demonstrated in our findings. In the current study, the technology was used as intended in only half of medication administrations. These deviations often originated in the dispensing process, such as not dispensed medications, wrong medication dispensed and wrong dose dispensed, and consequentially resulted in new deviations even when the BCMA was used correctly during medication administration.

The availability of functioning hardware is essential for the BCMA to have a preventive effect on errors. We identified a reoccurring problem with laptops not being charged and borrowing of scanners across wards, but these were not the main cause of technology-related deviations. The most important cause was the design of the technology like the bulky COW and the fact that scanners were not wireless. Those design issues limited the staffs' efficiency during medication administration. This may explain why 20% of patient ID wristbands were not scanned during observation. Others have also described the size of the medication cart getting in way of efficient use of BCMA.[4 18] One observational study concluded that nurses uniformly believed that manually confirming patient identity took less time than wheeling the large medication cart in the patient room.[27]

The distant medication rooms indirectly affected patient safety because retrieving of missing medications in the COW took a long time and led to medication omissions. Other environmental factors were in direct conflict with patient safety. Dispensing omissions were unavoidable because medications larger in size (eg, eyedrops, inhalers or syringes) could not fit in the small pocket of the COW patient drawers. Such environmental characteristics have affected medication safety in other studies as well.[30]

Our nurses also expressed that BCMA prolonged the time they spent on medication administration. Compared with others that used automated dispensing cabinets,[18] or pharmacy-operated dispensing,[12] it is important to stress that nurses in our study had more tasks to attend to during the dispensing process (eg, packaging, labelling, dispensing in the correct compartment of the patient drawer). This is likely to explain the high proportion of dispensing deviations in the current study.

This study demonstrates variations among nurses in their BCMA use: from not using the BCMA in entire administrations, to partial use, to those who were fully compliant. Much of the variability can be explained by

doses lacking barcodes and that the policies allowed for too many variations in the workflow. In the study of Barakat and Franklin, the BCMA led to less variability in how nurses undertake medication administration.[29] Some of this difference may be explained by safety culture differences, for example, if the BCMA technology is not used by all nurses, such as found in our study, it could result in being a burden to the workflow rather than a safety initiative. Lyons *et al*[31] have also described a similar performance variability among nurses within the use of other medication administration technologies, and addressed that this adaptive behaviour could be a source of resilience, compensating for the weaknesses of the system, but raised concerns that it could also lead to unsatisfactory outcomes.

Implications

Having the advantage of studying the use of BCMA within the actual setting, this study may provide implications to technology implementation and strategies for improvement.

- Prior to implementation, hospitals should risk-assess policies and make institution-specific decisions on how to properly integrate the technology into their workflow.
- The scanning rates could be improved if a greater number of medications are scannable. One way to address this is for the pharmaceutical industry to barcode medications on the primary packaging.[32] This could reduce the workload for the nurses and the hospital pharmacy and increase the standardisation of the dispensing process across wards.
- Ward-based medication dispensing, which is associated with significantly more medication errors than a unit-based system,[33] should be evaluated for efficiency and safety.
- Redesigning technology to fit the nurses' workflow, that is, replacing the cumbersome COW with a lightweight cart and mobile eMAR device, could create better experiences for nurses and compensate for the downsides of the currently implemented system.
- Greater attention to the usability and functionality of BCMA is required: override logs and scanning stats were not available within the BCMA system observed in this study, which limits the monitoring of the technology use significantly.
- Besides data monitoring, ongoing assessments of the actual use of the BCMA technology are mandatory as changes in policy and technology will lead to new deviations.[16] This could be accomplished through periodical observation of medication rounds,[13 34] which give an insight in the technology use with all the contextual factors in place, but also to involve end-users in making suggestions on improvement.
- Shared learning of BCMA practices between hospitals with similar systems is an important resource to improve knowledge, implementation, and staff motivation.

Strengths and limitations

The mixed-method approach provided insight into the nurses' BCMA use and understanding of the context in which deviations occur. The added value of using both the qualitative and quantitative data was that it identified frequency of deviations and their probable causes. Our observational tool allowed the detection of 'normal' deviations in practice (eg, dispensing wrong dose of medications) that often remain undetected because they are not identified using standard methods such as incident reports and chart reviews.[35] Previous studies have demonstrated that BCMA can reduce medication error rates.[4 5 7 8] In our study, the identified policy deviations indicate that workarounds occur due to system flaws that produce latent conditions which could ultimately lead to serious medication errors. However, focusing on policy deviations rather than medication errors is also a limitation because there is no direct measure of the impact of BCMA to patient safety.

Other limitations are acknowledged. First, there could be differences among observers, either in their data collection or in their interpretation and knowledge of local policy. Observers were carefully trained in observational techniques[36–38] and familiarised with local medication management policies to minimise such effect. Second, the presence of an observer might have influenced the nurses to consciously or unconsciously modify their behaviour.[39] Nurses were aware of being observed while administering medications, and the expected change in behaviour would have been in the direction of better compliance with BCMA use. Some nurses indicated that they were using the technology because they were being observed. However, the findings associated with the medication dispensing were not affected by the observation because this activity took place prior to the observation period that is, usually undertaken by nurses from the previous shift.

We studied an eMAR paired with BCMA technology in a hospital with a traditional ward-based medication dispensing operated by nurses. It is likely that our data will not be generalisable to organisations that use a pharmacy-operated or automated medication dispensing. On the other hand, hospitals that use a ward-based dispensing system can value from our findings, as there is limited research on the BCMA technology use in a ward-based medication dispensing.

CONCLUSION

This study provides an in-depth understanding of how the BCMA is used in the clinical environment. We identified policy deviations for over half of the observations, such as not scanning the patients or the medications, omission of dispensing, or wrong dose dispensed. We also identified variations in how nurses used BCMA. Deviations were caused with unclear policies, policies that interfere with appropriate BCMA use, including the labor-intensive dispensing process,

as well as problems with technology design. Our findings suggest that several factors in the work system need reassessment and adaptation to nurses' workflow. Deviations are expected with technology implementation in any complex system. As such, analysing policy deviations in practice is an important method of identifying and addressing system weaknesses in order to achieve the full benefits of BCMA in terms of patient safety.

Acknowledgements The authors thank the nursing staff for their participation in the study. We also would like to acknowledge the contributions provided by the staff from the Southern and Eastern Norway Pharmaceutical Trust and the Department of Information and Communication Technology at the hospital.

Contributors AM and AGG conceived of the presented idea. KT, LM and AGG were involved in planning and supervising the work. AM took lead in the data collection, analysis and in writing the manuscript. All authors have read and approved the final version of the manuscript.

Funding This study was internally funded.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The study was approved by the institutional data protection board.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. Additional deidentified data from the observational tool or field notes are not available as participants did not agree to share this information with a broad audience.

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