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Frontline Nursing Staff's Perceptions of Intravenous Medication Administration: The First Step Toward Safer Infusion Processes-a Qualitative Study

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Frontline nursing staff's perceptions of intravenous medication administration: the first step toward safer infusion processes—a qualitative study

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ABSTRACT

Objectives Intravenous medication errors continue to significantly impact patient safety and outcomes. This study sought to clarify the complexity and risks of the intravenous administration process.

Design A qualitative focus group interview study.

Setting Focused interviews were conducted using process mapping with frontline nurses responsible for medication administration in September 2020.

Participants Front line experienced nurses from a Japanese tertiary teaching hospital.

Primary and secondary outcome measures The primary outcome measure was to identify the mental models frontline nurses used during intravenous medication administration, which influence their interactions with patients, and secondarily, to examine the medication process gaps between the mental models nurses perceive and the actual defined medication administration process.

Results We found gaps between the perceived clinical administration process and the real process challenges with an emphasis on the importance of verifying to see if the drug was ordered for the patient immediately before its administration.

Conclusions This novel and applied improvement approach can help nurses and managers better understand the process vulnerability of the infusion process and develop a deeper understanding of the administration steps useful for reliably improving the safety of intravenous medications.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Intravenous medication administration is a complex process. Intravenous administration errors continue to pose a threat to patients and safe medical care. Root cause analyses have revealed the types and frequency of errors often exacerbated during patient handovers. There remains a need to identify where in the process and why errors occur in this complex process and implement more reliable ways to prevent dangerous medication errors.

WHAT THIS STUDY ADDS

⇒ Nurses are responsible for the complex intravenous medication process. The study higlights that present training and practice norms fail to appreciate the complexity of the entire medication process and error-prone factors based on an oversimplified training model of the clinical process. Process mapping is an effective method in training and supporting nurses to better recognise and appreciate the ongoing pitfalls of the error prone, medication process.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Medication infusion errors caused by gaps in nurses' perceptions can be prevented, thus protecting patients. Changing training and audit processes to focus on the importance of nurses knowing the upstream and downstream processes of intravenous medication administration can contribute to effective patient handovers when multiple people are performing the infusion process. Our novel research approach clarifies the infusion process not only for field nursing personnel but also for clinical managers. Our recommendations can serve as the basis for safe and efficient implementation of intravenous medication process, optimal process preparation and be applied to adverse incident analysis.

BACKGROUND

Preventing adverse drug events (ADEs) and ensuring patient safety remain significant challenges in the delivery of healthcare services. Medication errors, which represent 19.4% of all adverse events, comprise the largest contributor to medical errors and preventable medical injuries.[1] Studies have reported patient deaths and harm following medication errors, particularly related to intravenous therapy, such as errors in drug, dose, dilutant and cross-contamination.[2 3] Intravenous-related medication errors are especially dangerous and typically more severe than oral medication errors due to the concentration, rapid infusion, direct absorption and severity of intravenous effects.[4] A recent study found that nearly 22% of hospitalised patients experienced preventable adverse events, with the primary cause being ADEs.[5] The outcomes

of intravenous medication errors for patients range from mild symptoms to protracted suffering, permanent injury or even death.[6] Notably, research indicates that at least 79% of ADEs are preventable.[7]

The intravenous medication administration process is complex and consists of multiple interlocking steps that involve several people, either at different times or simultaneously, and in different physical locations.[6 8 9] Medication errors often occur during changeovers in healthcare providers or shifts of personnel.[10 11] However, studies on adverse events associated with intravenous administration are limited in number.[12 13] Nevertheless, existing reviews have revealed the types and frequency of medication errors that occur during the four primary intravenous medication administration processes: prescription, transcription, preparation and administration. A lack of detailed knowledge about the preparation procedure and inadequate use of smart technology are the most common causes of intravenous medication errors.[12] Furthermore, inappropriate drug administration rates and rapid dosing tend to be the most frequent types of errors, which can be significantly reduced through the use of an intravenous infusion control pump and a targeted safety checklist for monitoring drug administration type, doses and rates.[14]

Various defence systems are effective in preventing errors of the intravenous administration process have been reported, including in a recent review.[15] Typical examples of defence systems include smart pumps, which have been shown to be effective in preventing errors. However, they can also introduce error-inducing factors, such as procedure deviations[16 17] and alert fatigue.[18] Furthermore, previously reported risk countermeasures have used root cause analysis (RCA) tools to identify why accidents occur and how to prevent their recurrence (US Department of Veterans Affairs and Veterans Health Administration National Center for Patient Safety) by incorporating resilience engineering techniques.[19 20] However, the RCA has shown limited success in preventing intravenous ADEs.[21] One of the challenges may lie in the fact that RCAs are only partially useful in identifying the complex interactions underpinning non-linear medication workflows and the temporal order of events.[22–25] Moreover, RCAs often fail to clarify the realistic occurrence of medication errors within the infusion process continuum and meaningfully prevent subsequent errors and harm.[26] Therefore, alternative methods are needed to supplement RCAs.[27]

Process mapping is a visual representation method used to depict the sequence of steps involved in a process, which can enhance a shared understanding of clinical processes among staff members.[26 28] Process mapping has been used in various healthcare settings, such as inpatient/outpatient services and primary care. Process maps yield process improvements through exploring mental models of users by assessing failure mode and effects analyses and the development of countermeasures.[26] Despite its potential, there has been a limited application of process mapping to intravenous medication error analysis and prevention.[29 30]

We aimed to identify the mental models used by frontline nurses during the intravenous medication administration process, which can influence their interactions with patients and the medication processes. The study aimed to gain a deeper understanding of the complexity involved in the intravenous medication administration process by examining the gaps between the models perceived by the nurses and the actual defined process of medication administration.

METHODS

Study design

A prospective qualitative study was conducted to explore the mental models of nurses related to intravenous medication administration. In this study, intravenous administration of drugs was defined as transvenous administration of drugs for hospitalised patients, excluding blood transfusions, transcentral venous drugs, one-shot injections and anticancer drugs, which are administered and observed in different ways.

Process mapping

Process mapping is a visual technique used to diagram activities, tasks and decisions within workflow to improve the overall process.[31] In this study, process mapping was used to capture the infusion process along a time axis and identify overlapping events and their inter-relationships.[32] Process maps can be created at different levels of granularity, ranging from a high-level overview of major process steps to a more detailed representation of each specific step or activity. In this study, the nurses were specifically instructed to focus on mapping the current clinic process as opposed to a desired process to identify the ongoing challenges and opportunities for meaningful improvement.[33]

This study involved mapping the entire intravenous medication administration process, starting from the physician's prescription to the completion of the medication infusion and clean-up process by nurses. Detailed walk-throughs and focused interviews (by MU) were used to clarify the process.[34] The study was led by an expert physician (MU) who oversaw patient safety efforts at a tertiary hospital. The preparation, administration and observation procedures were based on standard nursing procedures for tertiary hospitals outlined in the Nursing Skills manual. Subsequently, a pharmacist specialising in medication safety reviewed the process maps and identified any misconnections or omissions. Thereafter, the pharmacist and two nurses comprehensively discussed the maps to refine them and agree on the final process maps.

Setting and participants

A focus group interview was conducted with nurses from a Japanese tertiary teaching hospital in September 2020. Four practising nurses with extensive experience in the intravenous medication process, were selected for this

Table 1 Themes discussed in the focus group interviews

Theme I	Perceptions about the infusion process held by the field staff. The participants were instructed to write down their understanding of the IV medication process based on their experience and practice.
Theme II	Comparison of the process map with the field staff's perceptions of the infusion process. The participants were presented with a process map of the IV medication process and were asked to compare it with their own perceptions of the infusion medication process (ie, experiences, beliefs, norms, assumptions, methods, tools, barriers and facilitators).
Theme III	Identification of the important steps in process mapping. The participants were asked to discuss the steps they deemed most important in the IV medication administration process (ie, role-taking, tasks and responsibilities).
Theme IV	Documentation of the opinions expressed in the focus group interview. The participants were asked to share their thoughts and suggestions for improving IV medication administration.

IV, intravenous.

study and were recommended by the Hospital's Director of Nursing.

Data collection

The study used a semi-structured focus group interview using an interview guide (available on request) developed by the research team based on the techniques described by Krueger.[35] The questions used in the individual interviews were pilot tested and refined iteratively. The themes discussed in the focus group interviews are shown in table 1.

The focus group interviews were led by an experienced moderator (MU) who encouraged the participants to express their candid opinions about the process map. The moderator first asked the participants to write down what they thought of the infusion medication process, then showed them the prepared process map and asked for their feedback. The study used structured and planned prompts to reduce moderator bias. The focus group interviews were recorded and transcribed verbatim by a medical transcriptionist using a standardised format. Finally, the transcripts were proofread by each participant and the moderator to ensure accuracy and offer opportunity for participants to provide other feedback on the interview.

Data analysis

Descriptive statistics were used to analyse the participants' characteristics. The interviews were conducted in Japanese, and the Japanese transcripts were translated into English for subsequent analysis. The transcripts were independently coded for each conversation by two researchers who then held face-to-face, web conference and email meetings to discuss their opinions on the two independently assigned codes until thematic saturation was reached (MU, YF). Thematic saturation was deemed to have occurred when no new codes or categories were generated. Any disagreements were resolved through discussion until a mutual agreement underlying the reasons for coding was reached with 3rd researcher(PB).

Throughout this study, frequent conference calls and meetings were conducted to refine the codebook as various codes emerged during the analysis process. The codes related to similar phenomena were grouped into categories, which were independently developed from the codes until a consensus was reached. This led to a unified version of the categories and codes. In addition, new categories were added to the code list, and themes were derived from these categories and added to the code list. The code list was refined through further discussion and multiple revisions until the final code list was agreed on and established. One of the researchers (MU) translated the code list and transcripts into English. Subsequently, the three researchers shared the English version of the code list and transcripts through web meetings and independently extracted representative codes, categories, themes and quotations related to the four structured themes. The researchers evaluated the codes, categories, themes, quotations, context, internal consistency, frequency, intensity, specificity and extensiveness, as well as the overall objective of the study.[36] Finally, a researcher (PB) independently reviewed the validity of the representative codes, categories, themes and quotes provided by the two researchers over remote Zoom videoconference meetings.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

Process mapping

The intravenous infusion process is described in two separate ways, one for the clinical workflow at the nurse's station (figure 1A) and one in the patient's room (figure 1B).

The process mapping begins at the top-left corner of the upper sheet when a physician enters a prescription in the electronic medical record (EMR). The prescription is then verified by the nurses at their station. If the physician's order is past the pharmacy cut-off time, the nurse will pick up the medication herself/himself, as shown in this map. For orders made by the cut-off time, the drug and label are sent to the ward by the Pharmacy Department. The nurse uses them to begin the process, starting with the 'place drug on workbench' step on the map.

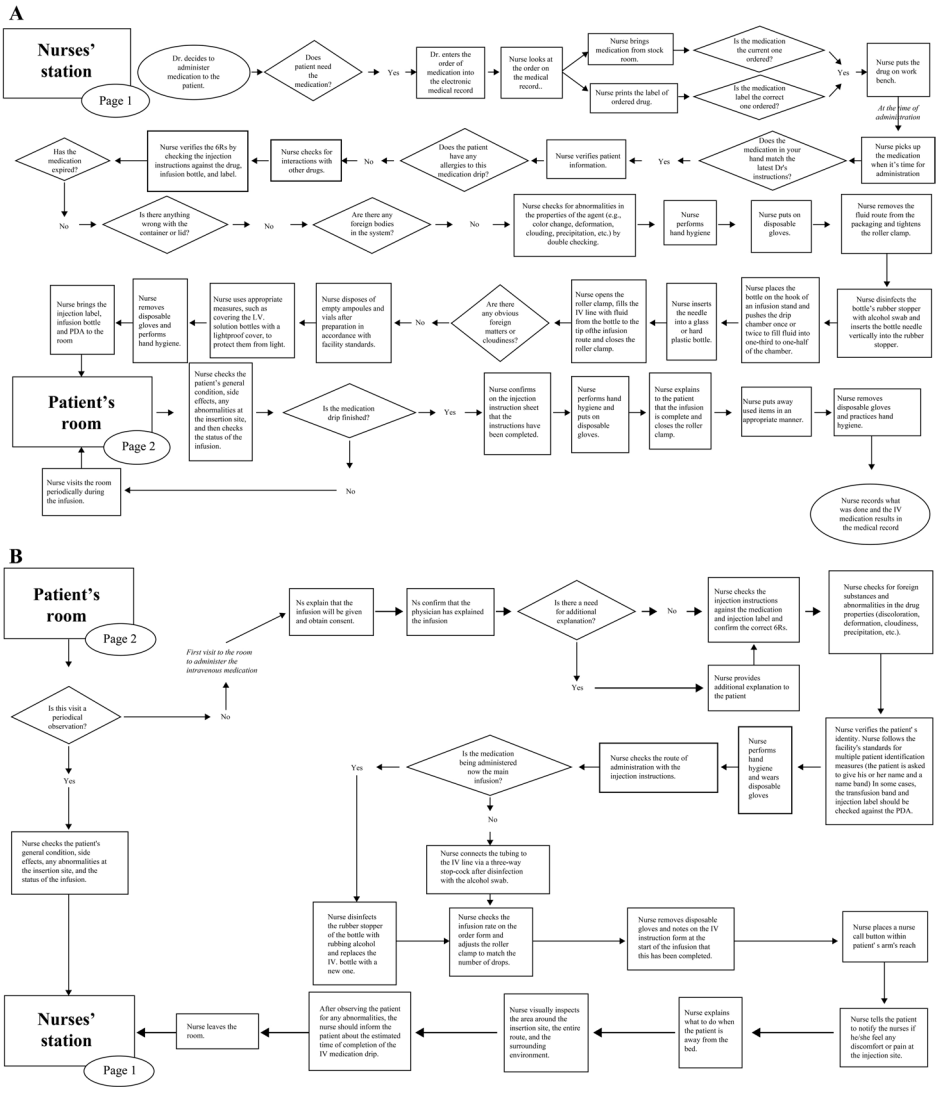

Figure 1 Process maps of the IV medication infusion procedure. (A) The process of IV infusion is described separately for the clinical workflow at the nurse's station. (B) The process of IV infusion is described separately for clinical workflow in the patient's room.

IV, intravenous; PDA, Personal Digital Assistant.

Following the drug preparation, the nurses enters the patient's room where the process starts at the top-left corner of the lower sheet and continues through to the lower-right corner. The steps involved in the patient's room are conducted in two sequences: (1) first visit, and (2) subsequent visits to the patient's room. After the nurses return to their station from the patient's room, the process resumes at the lower-left corner of the upper sheet, indicating that the process is completed as shown in the lower-right corner of the process map.

Participant characteristics

The focus group comprised four female nurses with an average age of 39 years (range: 36–44 years). The nurses possessed expertise in both management and practice and were members of the nursing department's leadership working group. The participants were recommended by the Director of Nursing to participate in the study. The data analysis resulted in four emerging themes: (1) understanding the infusion process as perceived by the field staff, (2) analysing the process map and comparing it with perceptions of the infusion process, (3) identifying the important steps in process mapping and (4) documenting the opinions expressed during the focus group interview.

Theme I: understanding the infusion process as perceived by the field staff

This study found that the actions of 'confirmation' or 'checking' through the use of a 'Personal Digital Assistant' (PDA) comprised the major components of the nurses' perceptions of the infusion process. These actions involve a variety of crucial aspects of medical care, such as confirming the patient's identity, drug type, dosage, purpose of use and route of drug administration. To prevent errors in these steps, nurses, doctors and other healthcare staff perform various confirmation actions, which have been labelled 'confirmation' in this study.

Table 2 Themes, categories, codes and quotes related to the nurses' perceptions of the infusion process and process map comparison.

Theme	Category	Code	Representative quotations
Bird's-eye view	Action	A series of actions	'We've been doing this much, haven't we?'
Bird's-eye view	Action	A series of actions	'When you show it like this, we can once again see how many actions there are.'
Bird's-eye view	Action	A series of actions	'We are certainly doing this in the field…'
Bird's-eye view	Action	A series of actions	'I think our process is oversimplified.' (laughter)
Actions necessary to ensure safety	Confirmation	Check (patient)	'I thought that checking the patient was an absolutely necessary procedure to avoid mistaking patients, and so I mentioned it.'
Bird's-eye view	Comparison	A matter of course	'A little strange… I didn't write the steps for preparation, such as removing the rubber plug, disinfecting, and stabbing the bottle of medication, because I thought everyone does it naturally.'
Bird's-eye view	Comparison	Same	'I think the procedure we wrote would have the same things in it. The same things are often written on the paper, such as 'starting the drip', 'checking the insertion site', 'changing the drip rate', 'always use a PDA', etc.'
Actions required to administer medication	Preparation	Receiving instructions	'We look at the prescription, and then we receive the instructions in the to-do list.'
			'When I receive the instructions, I make sure that medications are the right amount.'
Actions required to administer medication	Confirmation	Double-check	'Regarding whether or not the medication you pick up is consistent with the doctor's final instructions, we don't actually double check when it is picked up.'

PDA, Personal Digital Assistant;

Furthermore, the nurses expressed concerns regarding extravascular leakage and acknowledged the importance of effective communication with the patient *before* initiating the intravenous administration and exercising diligence when using the infusion pump.

Theme II: analysing the process map and comparing it with the perceived infusion process

The participants discovered upon reviewing the process maps that the infusion process consisted of more steps than they had originally envisioned. In contrast to the tasks that were deemed essential for drug administration (eg, connecting an intravenous line), the participants recognised that the confirmation step was 'not an essential action for administration but was necessary for patient safety'. The findings also indicated that some tasks that were routinely performed in the field were omitted from their process maps (table 2).

Theme III: identifying the important steps in the medication administration process mapping

The participants identified five important steps for ensuring safe intravenous medication administration: (1) receiving and reviewing the physician's orders, (2) checking the patient's allergy status, (3) confirming the patient and drug immediately before administration in the patient's room, (4) verbally communicating with the patient before leaving the room, and (5) conducting a series of safety checks to check for patient adverse events and that the infusions are being administered smoothly, and chekcing the patient after the medication infusion administration was completed (table 3).

Theme IV: documenting the opinions expressed during the focus group interview

The discussion was guided by the process maps, which allowed the participants to gain a visual understanding and deeper appreciation of the diverse mental models held by other healthcare providers regarding the entire infusion medication process. The following quotes from the participants effectively illustrate these diverse perspectives:

> I participated in today's discussion, and when I analyzed it objectively, I realized that, although I am doing all these detailed things in my head, each one of them is still important. It was surprisingly fun to talk about the things that I thought were important. (Nurse A)

> There are so many steps to be done in writing, but by doing it visually in this way, I was able to see how important it was and how I needed to be more careful about them. I also realized that there are many things that our bodies have already learned or that we take for granted in our minds. (Nurse B)

The categories inductively derived from the participants' opinions included 'importance', 'comparison' and 'safety', which were used to develop the 'bird's-eye view' graphic theme.

Table 3 Themes, categories, codes and representative quotes related to important steps in the IV medication process.

Theme	Category	Code	Representative quotes
Bird's-eye view	Importance	Important	'Anyway, I think it's important to make sure that the instructions match the work.'
Actions necessary to ensure safety	Preparation	Change instructions	'Whether or not the instructions given by the doctor and the prepared medicine match, there are times when the instructions change during the process of preparation.'
Actions necessary to ensure safety	Preparation	Doctor's instruction	'We never know, do we? If the instructions change, physicians should inform me, right?'
		Change instructions	
Actions necessary to ensure safety	Preparation	Doctor's instruction	'Even if doctors don't tell us, they often change instructions at the dispensary.'
		Change instructions	
Actions necessary to ensure safety	Preparation	Doctor's instruction	'When I call the doctor who gave the order, he says, "I'm sorry, I changed it."'
Actions necessary to ensure safety	Confirmation	Check (allergy)	'There are a lot of medications that are administered only after hospitalization. I thought it would be scary if I didn't have information on the allergies that were originally reported by patients.'
Actions required to administer medication	Confirmation	Check (infusion route)	'This means just before administration, right? So, you have to give the right drugs via exactly the right route and so on, don't you?'
		Check (drug)	
Bird's-eye view	Comparison	Important	'I think this is probably the most important part. This is where we do the final check before administering. That's because it would be a big problem if the drug or something had changed.'
Actions required to administer medication	Management	Talk to the patient	'For example, if something happens, if it's an adult, please call us right away, or if the patient has family members, please call us if something happens.'
Actions required to administer medication	Management	Dosing (complete)	'Did I do as instructed?'
Bird's-eye view	Importance	Disinfection	'I only circled disinfecting.'
Bird's-eye view	Importance	Disinfection	'Me too.'
Bird's-eye view	Importance	Records	'I also circled recording. For water balance, in and out.'
Actions required to administer medication	Management	Records	'It is not a lot.'

IV, intravenous.

DISCUSSION

The findings of this novel study demonstrate that front-line nurses experience considerable ambiguity in their understanding and implementation of safe intravenous medication administration, potentially contributing to patient harm. Process mapping can serve as a powerful training tool to enhance patient safety by providing front-line staff with a more nuanced understanding of their complex clinical workflow. Nurses can enhance their ability to administer intravenous medications by visualising the intricate process, identifying and analysing intravenous medication risks, and comprehending the entire intravenous medication administration process. The perceptions held by the nurses in charge of infusion operations primarily consisted of 'checking' drugs and patients, using a PDA and looking for abnormalities in patients' insertion sites as essential steps to mitigate infusion procedure risks. However, upon reviewing the entire infusion medication process using the process maps, the nurses discovered that other steps and risks were more involved than they initially expected. After examining the process maps, the participants identified five key steps that they considered important for preventing medication errors and patient harm. During discussions about the medication infusion process, the participants focused on confirmation-related steps and highlighted the importance of using PDAs for this confirmation step. Furthermore, the nurses compared and discussed the process maps based on defined procedures with the process they had envisioned. Upon reviewing the completed process maps, the participants gained novel insights into the number of key steps involved in the entire infusion process. In contrast, the nurses acknowledged that the process they had initially envisioned was incomplete and 'oversimplified'. This finding indicates that even experienced nurses may not fully understand the inherent *work-as-is* risks associated with intravenous medication administration versus the *work-as-imagined* perception.[37]

Therefore, nurses can benefit from reflecting upon and developing a deeper understanding of the entire workflow process involved in their daily work procedures.

Nurses play an essential role in ensuring safe medication administration to prevent errors and protect patients.[38 39] Both frontline workers and administrators recognise the importance of safe medication administration through safety checks.[40] In Japan, the Head Nurse manages the patient wards hands-on, while the other nurses including the nurses are responsible for administration of medications. The nurses who participated in the interviews for this study were not head nurses, but rather nurses who are in charge of practical and hands on clinical affairs. Previous research suggests that nurses may develop a false sense of security, assuming that errors will not occur as long as they conduct checks for adverse events and that infusions are being administered smoothly.[41] This perception was shared by the participants until they saw the process maps, which demonstrated that the confirmation steps were not mere routine actions but the most critical steps in preventing and detecting medication harm. Furthermore, previous research highlights that independent double-checks comprise an important step in the infusion process.[42] However, it remains unclear whether additional checks can effectively reduce medication administration errors. The infusion process involves several instances of 'checking' or 'confirming', and conventional error analysis may fail to clearly distinguish the relative importance or reliability of each of these process checks.[43] Thus, evidence of an effective process to reduce errors is critical to ensure that the resources and workflow disruptions associated with it are justified.[41 44] The cognitive workload on nurses, known to contribute to nursing bunout, increases with an increasing number of process checks to be performed. Therefore, it is crucial to perform only the minimum and necessary checks to detect errors. These findings suggest that frontline staff may perceive the intravenous medication administration process as having fewer steps than the actual defined procedures and may be biased toward medication confirmation. This bias can leave the patient vulnerable to the consequences of errors and lead to patient harm.

The nurses identified four additional steps beyond 'checking' in the intravenous medication administration process, namely, receiving instructions, checking for allergies, ensuring patients can call for assistance and performing post-intravenous infusion safety tasks. The process map highlighted a step where nurses prepare the medication after the physician enters it in the EMR. However, the nurses stated that they routinely 'check whether the doctor's orders are correct and promptly inform the doctor in case they are not'. Specifically, the procedure for physicians' prescriptions and confirmation in clinical practice should be consistent with preceding and subsequent procedures.[45] This involves an effective information handover within a process followed by a single professional and a separate handover procedure between different clinical professionals.[46] In addition, the issue of 'procedural deviations' has been identified as a cause of medication errors[47] due to limited education on the mechanisms of drug safety and reliability for nurses.[48] To address these challenges, the nurses proposed a method for administering intravenous drug infusions where the nurse directly responsible for the drug infusion step has a better understanding of their role in continuity with other procedures in the overall workflow, while the other nurses are responsible for upstream or downstream workflow actions related to the intravenous medication administration.

Nurses are well aware of the dangers associated with medication allergies.[49] In this study, the process maps underscored the importance of this step. Nurses often instruct patients to call for assistance when required, particularly during the first dose period or routine visits. However, some patients may be reluctant to use the call button, either because they do not want to bother the nurse or they underestimate the urgency of their situation. It may not be sufficient to merely inform the patients to, *Please call the nurses if you feel that you need assistance.* Instead, patients need to fully understand the risks of allergic symptoms, potential dangers and the importance of notifying the nurse immediately after adverse symptoms arise. Additionally, several post-infusion procedures were identified as important, though there were differences among nurses regarding the steps they considered valuable. While the primary step in medication infusion is 'administering the drug to the patient', equal attention is required in the 'post-action' process after completing the intravenous medication infusion. Undermining the 'post-action' process could lead to serious errors, such as missing a delayed drug reaction, mishandling contaminated intravenous equipment or leaving it unattended after its use.

The findings of this study allowed for two major developments: (1) improving the clinical infusion process, and (2) developing a new incident analysis method in our hospital. For the former, two further interventions were possible: one for frontline personnel and the other for the hospital administration. We developed and provided technical training for frontline clincial personnel regarding best 'techniques' related to intravenous infusion, such as connection and checking the infusion rate, but based on the findings of this study, 'the importance of a bird's-eye view of the entire infusion process' was also introduced into nursing education. The importance of clarifying which steps in the process are carried out and by which team member, and who oversees these steps in the handover process was also clarified and greatly appreciated.

We conclude that the hospital management, rather than simply establishing a new procedure and having their frontline staff carry it out, should be made aware of the need to describe more specifically the actions indicated in the procedure, based on the nursing personnel's awareness of the procedure. This 'sense-making' step helped implementation, such as placing greater emphasis

on the procedure in particularly important steps, such as verifying that the medication was prescribed to the correct patient just prior to administering it to the patient. Regarding the analysis of incidents, we realise we are only at the preliminary research stage, and now appreciate that an incident may contain errors at multiple inter-related steps. We are planning to analyse which errors and at which steps of the process are strongly related to medication errors as compared with other steps in the process. This kind of analysis would be useful in elucidating the deeper underlying mechanisms of accident occurrence, which has not been adequately revealed by previous single-step or RCA investigations. The findings of this study allowed for interventions by the field personnel and administration to reduce infusion errors. Furthermore, the study enabled further research to determine whether such interventions actually contribute to the reduction of infusion errors.

Limitations

Although the present study reveals important findings, it has several limitations. First, the process maps were based on the standard procedures of intravenous medication for hospitalised patients in a single large urban hospital, which may limit the generalisability of the findings to other healthcare settings. Second, the process maps may not fully reflect the differences in night and day shifts, ward and drug characteristics, urgency levels and outpatient administration processes. Thus, this study should be extended to other care settings to enhance the generalisability of the findings. Third, the focus group participants consisted of four experienced nurses, which may not fully reflect the views of less-experienced nurses or other professionals involved in the medication process. Inexperienced staff may think that they are adequately aware of the process, or they may think that the entire process is carried out while checking the procedures. However, since this study sought to determine 'how practitioners in charge of the infusion process think about the process', we targeted nurses with significant clinical and leadership experience. Fourth, the experiences of patients receiving medications were not directly reflected in the process maps. However, the importance of patient perspectives has been underscored in previous studies.[36 39] We stronly believe that patient involvement is key in co-designing clinical service interventions and should be examined in future studies.[50] Fifth, the study observed a tendency among the participating nurses to impose a linear structure and oversimplify a non-linear process.[51–53] Finally, the interviews were recorded and transcribed in Japanese before being translated into English, which may have led to variations in data interpretation.[54] Nonetheless, significant efforts were made to ensure methodological rigour and validity in the translation process, including the use of a standardised codebook and performing a pilot analysis. Furthermore, the current study conducted an ongoing internal quality audit adapted from two previous studies to ensure that data collection, analysis and reporting were in accordance with the study protocol.[55 56] The study makes a novel contribution to existing research as it demonstrates the effectiveness of process mapping in helping frontline nurses better understand their complex workflow and facilitate a comprehensive exploration of nurses' mental models regarding safe and reliable intravenous medication administration processes.

CONCLUSIONS

Process mapping serves as a powerful tool for enhancing medication safety and system's safety by visually charting the mental models of frontline staff and simplifying complex workflow processes for nurses and their clinical work environments.[57] The analysis revealed significant ambiguity regarding how to reliably and safely prevent intravenous ADEs. Our findings provide novel insights into nurses' perceptions of the significant risks associated with intravenous medication administration processes. Furthermore, the findings indicate that process mapping can be useful in revealing and surfacing frontline nurses' awareness of the infusion process. The findings of this study call for interventions by healthcare personnel and administration to further reduce infusion errors and examine how such interventions contribute to the reduction of infusion errors and to overall patient safety.

Further reading

- US Department of Veterans Affairs, VHA National Center for Patient Safety. Root cause analysis. https://www.patientsafety.va.gov/professionals/onthejob/rca.asp.

Contributors MU is a guarantor and takes full responsibility for the completed work and the conduct of the study, has access to the data, and controls the decision to publish.MU, YF and PB conceived the idea of the study. MU, YF and TO developed the qualitative analysis plan and conducted qualitative analyses. TK translated the results of interview in Japanese into English with no errors. MU, NK, TK, YF, TO and PB contributed to the interpretation of the results. MU and PB drafted the original manuscript. YF supervised the conduct of this study. All authors reviewed the manuscript draft and revised it critically for intellectual content. All authors approved the final version of the manuscript to be published.

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