

# Experience of Nurses with Intravenous Fluid Monitoring for Patient Safety: A Qualitative Descriptive Study

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**Purpose:** Medication administration is a complex process and constitutes a substantial component of nursing practice that is closely linked to patient safety. Although intravenous fluid administration is one of the most frequently performed nursing tasks, nurses' experiences with intravenous rate control have not been adequately studied. This study aimed to explore nurses' experiences with infusion nursing practice to identify insights that could be used in interventions to promote safe medication administration.

**Patients and methods:** This qualitative descriptive study used focus group interviews of 20 registered nurses who frequently administered medications in tertiary hospitals in South Korea. Data were collected through five semi-structured focus group interviews, with four nurses participating in each interview. We conducted inductive and deductive content analysis based on the 11 key topics of patient safety identified by the World Health Organization. Reporting followed the consolidated criteria for reporting qualitative research (COREQ) checklist.

**Results:** Participants administered infusions in emergency rooms, general wards, and intensive care units, including patients ranging from children to older adults. Two central themes were revealed: human factors and systems. Human factors consisted of two sub-themes including individuals and team players, while systems encompassed three sub-themes including institutional policy, culture, and equipment.

**Conclusion:** This study found that nurses experienced high levels of stress when administering infusions in the correct dose and rate for patient safety. Administering and monitoring infusions were complicated because nursing processes interplay with human and system factors. Future research is needed to develop nursing interventions that include human and system factors to promote patient safety by reducing infusion-related errors.

**Keywords:** intravenous infusions, medication errors, medication systems, nurses, patient safety

## Introduction

Intravenous (IV) administration of medications is one of the most common processes in the treatment of hospitalized patients, and a major component of nursing practice. During the medication administration process, errors occurred in about 30% of IV medication administration,<sup>1</sup> which in turn threatened patient safety and increased health care costs. In the US, medical errors cost the lives of up to 251,000 people annually,<sup>2</sup> and each year, the overall cost of caring for patients after medical errors is \$20 billion.<sup>3</sup> According to the National Reporting and Learning Service,<sup>4</sup> the rates of medication administration errors (MAEs) are still unacceptably high. Since the IV medication administration process is composed of multiple and complex steps, comprehensive factors that lead to medication errors should be considered to prevent possible errors and improve patient safety.

MAEs with IV medications have a higher risk of significant adverse effects than any other administration route because the IV route leads to near-instant absorption and dispersion into the blood stream.<sup>5</sup> Approximately 10% of MAEs were found to be IV-related, and 57.9% of the reported IV infusion-related errors were related to “wrong rate.”<sup>1</sup>

Previous studies have identified diverse aspects of risk factors for general medication errors. Ahn et al<sup>6</sup> focused on communications during handovers, which classified major themes based on need for partnership, lack of pertinent patient information, and interruptions/distractions. Daker-White et al<sup>7</sup> determined that patient, staff, system, or organizational factors are associated with patient safety. In addition, Parry et al<sup>8</sup> identified that “environment” and “person” were the contributing factors for the MAE behaviors of registered nurses (RNs). Environmental factors included clinical workload and work setting (ie, RN staffing and workload, organization, teamwork, and communication), whereas person factors included the characteristics and lived experience of work of RNs (ie, experience, fatigue, shift pattern, and quality of working life).

Identifying the causes of IV fluid MAEs during infusion is critical for patient safety. However, only a few studies have identified the causes of IV fluid MAEs focusing on infusion pump-related errors.<sup>9–11</sup> Previous studies also have limitations in comprehensively understanding the causes or risk factors contributing to IV fluid infusion MAEs because most studies used self-reported questionnaires to examine the incidence and causes of general IV MAEs. According to the survey study conducted in Iran,<sup>12</sup> the most common IV MAEs included wrong medication (27.1%) followed by wrong dose (17.9%) and wrong infusion rate (17.2%). In addition, the study<sup>12</sup> addressed that the most common causes for IV MAEs were heavy workload (51.5%), inappropriate packaging (24%), and poor communication between team members (13.3%). The result implies that it is important to provide staff education, establish a standard ratio of nurses to patients, and improve communication between nurses and physicians.

IV fluid infusion is one of the most frequent nursing tasks, and nurses occupy a key position in the medication administration process since they administer medications directly to patients. In terms of identifying the causes of infusion-related errors for patient safety, nurses’ perception on such errors should be thoroughly explored. However, few studies have fully analyzed nurses’ experiences regarding IV fluid doses and rate control. Therefore, this study aimed to explore nurses’ experiences with IV fluid infusion nursing practice to obtain insights that could be used to promote patient safety and reduce infusion-related errors.

## Methods

### Design

This qualitative descriptive study used focus group interviews, which the authors guided using pre-organized semi-structured questions (Table 1). The interview questions were constructed based upon the ecological system theory of Salazar and Primomo.<sup>13</sup>

### Participants

Purposive sampling was used in this study. Participants were recruited from April to June 2021. The inclusion criteria were as follows: (a) RNs in South Korean tertiary hospitals, (b) nurses who frequently performed medication administration tasks, and (c) participants who voluntarily agreed to participate in the study and data collection. Nurses who did not provide direct patient care were excluded. The focus groups consisted of nurses who performed IV fluid infusions for a wide range of patients, encompassing the full scope of the lifespan from neonatal to older adults, in general wards, emergency rooms (ERs), and intensive care units (ICUs). We created five groups consisting of four nurses who worked in units with similar working environments. This is because homogenous group members tend to feel comfortable to share their experiences on medication administration processes, types of medications, IV fluid infusion devices, and MAEs. For example, the first and fifth focus group interviews were conducted with nurses working in adult/geriatric general wards, the second was with nurses working in specialized units (such as ICUs and ERs), the third with nurses working in pediatric wards and neonatal ICUs, and the fourth was with new nurses who had less than one year of clinical experience.

**Table I** Interview Guide Questions

Type	Specific Questions
Introductory questions	- What medication administration errors (MAEs) or near misses have you experienced recently?
Transition questions	1. Experience with MAEs and near misses - How do you feel after experiencing an MAE or a near miss? - What do you think is the cause of these errors you have experienced? - What do you think needs to be improved to prevent these errors?
Key questions	<p><b>Micro-systems</b></p> <p>2. Attention during medication administration</p> <p>- How do you take care to reduce mistakes when administering medication?</p> <p>3. Workload and fatigue</p> <p>- What are your medication administration tasks?</p> <p>- What is your workload like?</p> <p>- How is your work stress?</p> <p>- What is the physical and psychological burden of your medication administration tasks?</p> <p>- How tired do you feel about your medication administration tasks?</p> <p><b>Social network</b></p> <p>4. Environmental factors (hospital units)</p> <p>- What is the safety culture of your unit?</p> <p>- What is the work environment like among the staff in your unit?</p> <p>- How does the chief of your unit respond to patient safety incidents?</p> <p>- How do staff in your unit react to patient safety incidents?</p> <p>- What is your unit doing to improve patient safety incidents?</p> <p>- What is your unit doing to reduce MAEs or near misses?</p> <p><b>Institutional systems</b></p> <p>5. Institutional factors (hospital):</p> <p>- What is the safety culture of your hospital?</p> <p>- What is the working atmosphere between departments in your hospital?</p> <p>- How does your hospital respond to patient safety incidents?</p> <p>- What is your hospital doing to improve patient safety incidents?</p> <p>- What is your hospital doing to reduce MAEs and near misses?</p>
Ending questions	- Is there anything else you would like to say more about what we talked about today? - Are there any opinions that you would like to be reflected if a fluid-rate monitoring device is developed?

## Data Collection

The focus group interviews were conducted in June 2021. Five focus group interviews were sequentially conducted, and each involved four RNs. Each interview lasted between 90 and 110 minutes. The interviews were facilitated by one main moderator and one assistant moderator. To establish trustworthiness in reflecting the participants' perspectives without bias, it was ensured that all moderators were not affiliated to the participants' institutions and did not have any conflict of interest. The moderator explained the purpose of the study and encouraged the participants to freely share their experiences based on the semi-structured interview questions.<sup>14</sup> The open-ended questions were related to the nurses' experiences of IV fluid infusion nursing practice, workload, fatigue, the safety culture of their units, and activities of hospitals to improve patient safety. In addition, we collected demographic data of the participants including their gender, age, length of clinical experience, working unit, number of assigned patients, and education level.

To ensure credibility, participants were encouraged to support their statements with detailed examples, and the moderators asked follow-up questions based on prolonged engagement and persistent observations. Data collection proceeded until data saturation was achieved (ie, when there were no more emerging concepts or novel statements). The interviews were conducted through an online meeting program (Webex). The focus group interviews were audio-recorded, and field notes were simultaneously taken if needed. Demographic information was collected before the interview using Google Forms.

## Data Analysis

To ensure credibility, the focus group interviews were audio-recorded and transcribed verbatim. The verbatim transcriptions and field notes were used for data analysis. Research team members constantly read and re-read the verbatim transcriptions and analyzed the following process. Data were analyzed and interpreted based on Ricoeur's phenomenological hermeneutical philosophy.<sup>15</sup> This approach provides new insights through being-in-the-world to reach an in-depth understanding of nurses' experiences. In the first step of the analysis, the naïve reading process, the goal was to understand the meaning of the texts as a whole by reading and rereading the transcripts. In the second step, texts were split into units of meaning. This led to the last step of analysis: identification of patterns and themes for a comprehensive understanding. In the structural analysis, we used inductive and deductive content analysis.<sup>16,17</sup> The deductive content analysis was based on the 11 key topics of patient safety that the World Health Organization (WHO) identified.<sup>18</sup> Subsequently, all emerging themes were inductively categorized. Finally, the revealed themes were refined by an active discussion to reach a consensus among the researchers. Data analysis proceeded until no further themes were derived from the interview data. To achieve transferability, a rich description of the related themes, including participants' experiences and the contextual aspects, was provided. To ensure dependability and confirmability, the research process notes, including that of the interview process, raw data, analysis notes, and coding notes, were reviewed by a qualitative research expert, who was not part of the research team. Qualitative data were reported following the consolidated criteria for reporting qualitative research (COREQ) guidelines.<sup>19</sup>

## Results

**Table 2** presents the participant characteristics. In total, 20 RNs participated in the focus group interviews. Their mean age was 27.30 years (SD = 4.21), and 19 of them (95%) were women. Participants' clinical experience ranged from 3 months to 208 months, and they worked in various units including general wards, ICUs, ERs, and pediatric units. The patient-to-nurse ratio varied across units, from less than five patients (eg, ICUs) to 11–15 patients (eg, general wards). The majority of participants (n = 17) had bachelor's degrees.

Two central themes emerged regarding nurses' experiences with IV fluid infusion nursing practice: human factors and systems (**Table 3**). Human factors had two subthemes: individuals and team players. Individual elements were further categorized into three content areas: nurses' distress with infusion problems, patients' physical/mental conditions, and the proportion of infusion nursing tasks in the routine workflow. Team players were categorized into three content areas: providing peer backup, inter-professional communication, and engaging with patient and caregivers. In terms of system factors, three subthemes and six related content areas regarding nurses' experiences with IV infusion nursing practice were identified: institutional policy (lack of nursing training and standardized guidance and high patient-to-nurse ratios), culture (blame culture and efforts to reduce MAEs), and equipment (need for reliable infusion equipment and need for advanced monitoring equipment for patients in isolation rooms). The identified themes have been described and supported by quotations to give examples of findings from the interview data. All the quotes were translated from Korean to English, and all authors agreed on the translations. The data were anonymized, and the four participants of each group were referred to as Participant A, B, C, and D.

## Theme I: Human Factor

### Individuals

#### Nurses' Distress with Infusion Problems

Infusion nursing practice requires frequent monitoring to prevent possible errors, which often makes nurses spend a considerable time on the task. One nurse expressed that after an adverse event involving the over-infusion of IV fluids, the stress that originated from the error was so severe that the participant even thought about quitting the job. Similarly, other participants experienced stress, anxiety, and guilt while performing infusions since infusion errors are closely associated with patient safety.

**Table 2** General Characteristics of the Participants (N=20)

Characteristics	Categories	n (%)	Mean±SD (Range)
Gender	Female	19 (95.0)	
	Male	1 (5.0)	
Age	23-<25	5 (25.0)	27.30±4.207 (23–40)
	25-<30	12 (60.0)	
	≥30	3 (15.0)	
Clinical experience (month)	<12	4 (20.0)	47.30±45.779 (3–208)
	12-<36	6 (30.0)	
	36-<60	5 (25.0)	
	≥60	5 (25.0)	
Working unit	General ward (medical/surgical)	11 (55.0)	
	Intensive care unit	3 (15.0)	
	Emergency room	2 (10.0)	
	Pediatric unit	4 (20.0)	
Number of assigned patients	≤5	8 (40.0)	
	6–10	9 (45.0)	
	11–15	3 (15.0)	
Education	Associate	1 (5.0)	
	Bachelor's	17 (85.0)	
	Master's	2 (10.0)	

**Table 3** Central Themes and Subthemes Related to the Nurses' Experiences Regarding IV Fluid Infusion Nursing Practice

Central Theme	Subtheme	Content
Human factors	Individuals	Nurses' distress with infusion problems
		Patients' physical/mental conditions
		Proportion of infusion nursing tasks in the routine workflow
	Team players	Providing peer backup
		Inter-professional communication
		Engaging with patients and caregivers
Systems	Institutional policy	Lack of nursing training and standardized guidance
		High patient-to-nurse ratios
	Culture	Blame culture
		Efforts to reduce medication administration errors
	Equipment	Need for reliable infusion equipment
		Need for advanced monitoring equipment for patients in isolation rooms

- I find overloading to be the hardest problem to deal with. When patients with pulmonary problems have a sudden effusion, they need immediate intubation and must be transferred to the ICU. This creates terrible guilt. I have even encountered many nurses who carry the burden of guilt to the point of contemplating resignation. (Group 1\_Participant A)

### Patients' Physical/Mental Conditions

All participants agreed that the rate of IV infusion is largely dependent on the patient's physical and mental conditions. Patients' physical conditions that might affect IV infusion status include age, vessel condition, and position, while relevant mental conditions include mental status or delirium.

- The attributes of blood vessels are important, but I believe age is also a very important factor. Patients in their 20s and 30s are more aware of their conditions. Therefore, if we happen to overload the fluid, they quickly recognize it and inform us. However, elderly or cognitively impaired patients often do not recognize fluid overload, which delays the appropriate treatment. (Group 5\_Participant D)

### Proportion of Infusion Nursing Tasks in the Routine Workflow

Participants had different opinions regarding the proportion of infusion monitoring tasks in nursing practice. Some nurses stated that medication administration accounts for a large proportion of nursing practice and has a high priority. However, other nurses stated that even though it is a burdensome task, it does not account for the majority of the nursing workload and does not cause overtime.

- Even when we are busy, we check whether or not the fluid is being administered well. We tend to prioritize monitoring the fluid. (Group 3\_Participant B)
- I also feel burdened by the task of fluid monitoring, but it does not lead to overtime. I do not think the task is so burdensome and takes up more than half the workload. (Group 4\_Participant B)

### Team Player

#### Providing Backup for Peers

Participants agreed that collaborative work with fellow nurses in the same unit is important for infusion nursing practice. Since nurses help each other in emergencies or busy situations for patient care, teamwork is important.

- In cases of cardiac arrests, I ask a new nurse to remain at the nurse station. When necessary, I ask them to do the rounds for fluid monitoring. (Group 4\_Participant D)

### Inter-Professional Communication

Participants explained that challenges related to interactions with other health-care professionals exist, and that physicians often gave incomplete prescriptions or omitted some information. Miscommunication during handovers with health-care professionals from other units may also cause IV loading accidents.

- When "1 L" is prescribed [omitting the information of how long to administer], we usually administer 40 cc/hr throughout the day. ... However, some doctors do not give specific administration instructions and complain later that they intended to administer 20 cc/hr. (Group 5\_Participant D)

### Engaging with Patients and Caregivers

Since nurses take care of numerous patients, patients and caregivers often help the nurses by notifying them of any problems. However, they sometimes caused MAEs due to their lack of knowledge and curiosity about operating the pumps.

- Specifically, I draw a line on the IV fluid bag with a marker and ask the caregiver to page me when the fluid level goes below it. Thus, the caregiver keeps an eye on the fluid bag and helps out. (Group 1\_Participant C)
- Some patients and their caregivers think that more fluid is good for them ... Young patients play with the wheel [of the syringe pump] for fun. Sometimes, they turn it to the point that it infuses excessively. (Group 3\_Participant B)

## Theme 2: Systems

### Institutional Policy

#### Lack of Nursing Training and Standardized Guidance

The hospitals where the participants worked provided nursing training programs for new nurses. However, the participants agreed that education related to infusion nursing practice was mostly acquired through ad hoc experience rather than a systematized process.

- New nurses take numerous tests on infusion rates during the training program until they pass. They are also trained on intravenous administration. But I wish the training was a bit more in-depth because most new nurses perform the task exactly as they learn it during the training. (Group 1\_Participant A)

### High Patient-to-Nurse Ratios

The patient-to-nurse ratio shows the number of patients one nurse cares for on a shift. High patient-to-nurse ratio could increase the risk of MAEs.<sup>20,21</sup> As most participants had to provide care for six to ten patients on a shift, they were occupied with many other nursing tasks, making it difficult for them to frequently monitor the infusion status.

- [Because I had to provide care for 10 patients on my shift,] once I load the IV fluid bag, I educate the caregiver or family member about the fluid level. ... I tell them to come to the station and let us know when [the target amount of] fluid has been administered. I educated caregivers to minimize overloading accidents like this. (Group 4\_Participant D)

### Culture

#### Blame culture

Participants were afraid that they would be scolded if they did not meet the target amount of IV fluid administration when they handed over patients to a senior nurse. This fear led nurses to adjust the fluid rate accordingly to meet the targeted volume before the shift report to avoid being criticized during the handover. Nurses were also stressed about reporting incidents of MAEs to the attending physician because of some physicians' negative reactions to MAEs.

- If new nurses fail to administer the planned amount of fluid to the patient, they feel extremely uncomfortable during the handover report to a senior nurse. As the time for handover approaches, they increase the flow rate, causing serious problems. (Group 5\_Participant D)
- There was a huge discrepancy between the target and patient's I/O [intake and output], and one of the attending physicians told me to report the I/O every 30 minutes for a patient who was receiving eight medications, which was a really absurd prescription. ... [Due to this responsibility,] I could not do other jobs. When I failed to report once, the attending physician scolded me for non-compliance, assuming that I had disregarded the order. (Group 2\_Participant C)



### Efforts to Reduce Medication Administration Errors

Each unit has its own unique values that influence nursing practices. Participants shared their units' unique cultural practices that were introduced to reduce MAEs, such as implementing campaigns, placing a small sign on patient poles saying not to operate the infusion device, and putting stickers on each infusion pump to easily monitor which fluid was being infused and at what rate.

- Each care unit has a “safety keeper” who manages fluid administration. The safety keeper performs a small unit-wide campaign every month regarding what needs more thorough monitoring based on the safety team's protocols. (Group 3\_Participant A)
- When we look at the fluid itself from afar, we cannot tell what is in the fluid bag. Even though we know by heart which IV fluid should be administered at what rate, just looking at the bag can be confusing. Just in case other people ask “What is in the bag?”, I put a sticker on the pump to make it easy to check which fluid is administered at what rate. (Group 2\_Participant D)

### Equipment

#### Need for Reliable Infusion Equipment

Medication administration devices have been introduced to reduce infusion-related medication errors. However, they often do not operate at the exact rate of their settings or entail other problems.

- Everyone knows that the rates on the control set are not accurate. Depending on the condition of the patient's vessels, there could be a huge discrepancy. (Group 1\_Participant A)
- When it comes to the desired drip rate, children do not have strong veins that can handle the full rate and end up having a ruptured blood vessel. Even though the device allows us to administer the medication at the desired rate, it can cause blood vessels to swell. (Group 3\_Participant A)

#### Need for Advanced Monitoring Equipment for Patients in Isolation Rooms

Participants stated that wearing personal protective equipment for infection prevention and control is cumbersome, delays nursing tasks, and increases the workload. They agreed that it is difficult to monitor the infusion status and hear alarms from outside an isolation room.

- Each time I entered, I had to put on new protective equipment. ... Eventually, I had to use my eyes to check whether the fluid was being administered [from the outside] (Group 1\_Participant C)
- Last year, I was dispatched to a unit for suspected COVID-19 cases. To enter the area, I had to wear a full-body suit. I had to wear it even to just check the alarm of an I–vac pump, making my workload more burdensome. (Group 2\_Participant A)

## Discussion

Our study explored nurses' experiences with IV fluid infusion nursing practice, which promotes or disrupts medication administration safety. Based on the 11 key topics of patient safety proposed by the WHO—patient safety, human factors, systems, team players, learning from errors, clinical risk, quality improvement, engaging with patients and caregivers, infection prevention and control, patient safety and invasive procedures, and medication safety,<sup>18</sup> the inductive and deductive content analysis revealed two central themes: human factors and systems. Human factors had two subthemes (individuals and team players), and systems consisted of three subthemes (institutional policy, culture, and equipment). Some contents of the subthemes (eg, patients' physical/mental conditions) were solely found within the theme of human factors. However, most of the contents were found within both human factors and systems. These patterns of interlinking relationships between the human factors and systems are consistent with the findings of a qualitative systematic review on nurses' perceived causes of MAEs that synthesized 16 articles.<sup>22</sup>



In terms of human factors, participants expressed high levels of distress due to infusion problems, including stress, anxiety, guilt, or tension related to underdose or overdose infusion errors, which are potentially harmful to patients. Similarly, a study of nurses' experiences of negative feelings termed this phenomenon the "second victim syndrome" after infusion-related errors.<sup>23</sup> These negative emotions stem from the adverse events and nurses' professional responsibility to not harm patients. Thus, when developing nurse training programs for safe medication administration, it is also important to encourage nurses to share their concerns regarding the management of IV fluid. Second, all participants were worried about the possibilities of wrong volumes or rates of IV fluid while on shift. They pointed out that the patients' physical or mental conditions (such as age, vessel conditions, position/posture, or delirium) could interfere with the right volume or rate of IV fluid. Similarly, a focused interview study found that patient-related factors, including their confusion, aggression, memory loss, and attitudes, were challenges in medication administration.<sup>24</sup> This implies that it is important to include patients and caregivers as team players to reduce the adverse events in medication administration. For example, nurses can educate patients/caregivers regarding the potential adverse events related to IV infusion therapy, and ask them to collaborate when IV starts or inform when they recognize signs of potential adverse events such as skin inflammation, accidental disconnection of the infusion, or the infusion pump setting off the alarm.<sup>25,26</sup> Third, the participants reported different proportion and prioritizations of infusion monitoring tasks in their practice. While some nurses considered infusion nursing practice as a high-priority nursing task, others stated that infusion nursing practice was burdensome since the tasks required frequent monitoring, but did not take up most of their nursing practice. Since nurses spend up to 40% of their shifts administering medications,<sup>27</sup> these different perspectives on the proportion of infusion nursing care might reflect differences in clinical settings, the severities and complexities of patients' diseases, levels of nursing skills, or the collaborative culture of their workplaces.

Another subtheme of human factors was "team players." This subtheme refers to factors that promote collaboration to reduce MAEs. The "team player" elements were categorized into three content areas: providing peer backup, inter-professional communication, and engaging with patients and caregivers. These results are consistent with several meta-synthesis studies.<sup>6,7,22</sup> Of particular note, in this study, "engaging with patients and caregivers" is a relatively new content area compared to other studies regarding IV infusion nursing care. This can have advantages and disadvantages. In general ward settings, working together with patients or caregivers can be helpful in monitoring IV infusions; for instance, patients or caregivers can notify the nurse of an infusion pump alarm or volume status. Instead, engagement with patients and caregivers should be considered as an enhanced opportunity for both to actively give their opinions regarding IV fluid management to improve infusion nursing processes and quality.

In terms of system factors, participants experienced inefficient institutional systems, specifically a lack of nursing education and high patient-to-nurse ratios, which affect patient safety regarding IV medication administration, although some participants highlighted quality improvement projects for patient safety. These personal-system interrelated issues made it difficult for nurses to frequently monitor IV fluid administration status, as has been regularly reported in previous studies and meta-syntheses.<sup>7,22,24</sup> Compared to institutional-level barriers, unit-wide barriers (eg, blame culture) can be relatively easy to change. As discussed earlier, participants expressed distress with monitoring the right volume or rate of IV medication administration. One of the factors causing distress was blame culture, particularly the reactions of senior nurses if they did not meet the planned amount of IV fluid administration. In the context of South Korean hospital unit culture, hierarchical environments can lead the power imbalance between senior nurses and novice nurses, and negative reactions during handover can affect the novice nurses' nursing practice. This result is consistent with the findings of a systematic review and qualitative meta-synthesis.<sup>6</sup> Each unit has its own unique culture that influences attitudes and practices within the unit, and participants also shared their units' cultural practices that were introduced to reduce MAEs and promote patient safety. A clinical implication of this finding is that such practices can be applied to each unit's culture in creative ways, such as using stickers or campaigns against blame culture.

Furthermore, participants experienced a lack of reliable and user-friendly IV monitoring equipment. They commonly reported that the rates of the infusion control set were not accurate because the IV fluid drip rates seemed affected by the viscosity of IV medications or patients' vein status. Some participants described that "using the control set was meaningless", and they needed to adjust IV fluid rates manually while using mechanical infusion pumps or control sets. Even though infusion equipment is useful to administer medications at a planned rate, the planned drip rate can sometimes cause the blood vessel to swell, or vice versa, unnecessary sensor alarms can occur. Several studies have reported equipment issues.<sup>10,28</sup> In addition, participants pointed out the need for advanced monitoring equipment for patients with infectious diseases in isolation rooms.

Nurses often had to wear personal protective equipment, and enter and exit through double-doors only to monitor IV fluid rates. In the pandemic situation, this process was “very burdensome” and ineffective for patient care.<sup>29,30</sup> Thus, technical support, such as reliable and user-friendly infusion equipment, should be developed and implemented.

This study has several limitations. We conducted focused interviews with nurses who worked in settings ranging from general wards to ERs and ICUs, with pediatric to adult patients. However, this study was only conducted at two urban tertiary hospitals. The findings, therefore, may not be generalizable to other nursing settings and rural areas. Several suggestions are provided for further studies. There is a need for more quantitative studies developing and testing integrated interventions, including human and system factors. For example, interventions can be developed for new graduate nurse training, improvement of inter-professional communication skills, patient and family engagement, or facilitation of safety culture. Furthermore, it is important to develop and test accurate equipment that fully reflects nurses’ clinical experiences. It would be particularly helpful to develop IV infusion equipment that would reliably adjust for the viscosity of IV medications or patients’ vessel conditions and detect the actual amount of infusion fluid for the nursing/medical staff to provide infusion care for patients in isolation rooms or other types of remote health care settings under pandemic conditions.

For implications for practice regarding safe medication administration, nurse training programs should include sharing nurses’ distress on infusion care, providing peer backup, and inter-professional communication skills that affect nursing practices. It is also important to include patients and caregivers as team players to reduce the occurrence of adverse events in medication administration. Simultaneously, system factors, such as improving workforce issues, developing standardized guidance, or reducing the blame culture should be considered. Furthermore, technical support, such as reliable and user-friendly infusion equipment, should be developed.

## Conclusion

This study found that nurses experienced high levels of stress during IV fluid monitoring tasks in terms of administering the correct dose and rate for patient safety. Administering and monitoring infusions were complicated because nursing processes interplay with human and system factors. In this study, nurses’ experiences on infusion nursing process have clinical implications to improve the nursing process, unit cultures, communication skills, or institutional policies, regarding infusion nursing practice, for increased patient safety. Future research is needed to develop nursing interventions that include human and system factors to promote patient safety by reducing IV MAEs. MAEs with IV medications have a higher risk of adverse effects than any other administration route. In acute care settings, nurses play an important role in medication administration process. This study provides profound lived experiences of nurses performing infusion nursing care.

## Ethical Consideration

The study was conducted after obtaining ethical approval from the Institutional Review Board in Yonsei University (Y-2020-0241). Informed consent was obtained from all participants. It was explained that confidentiality and anonymity would be guaranteed and that they could withdraw from the study at any time upon request. They were also notified ahead of time that all interviews would be recorded simultaneously.

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## Disclosure

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