ORIGINAL ARTICLE

Accident prevention "awareness" system for intravenous drip infusion operations: Construction and evaluation

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ABSTRACT

The "Kitzuki" System was developed to produce an infusion system in place of traditional infusion pumps to prevent errors in infusion rates. This study investigated this system's advantages and disadvantages in a medical setting. The system works to monitor the drip rate and send alerts to the nurse call system in cases where there are deviations from preset parameters. The system was trialed with 24 nurses and a survey was conducted to assess its usability in practical settings. All 24 respondents (100%) reported that the system's specifications and usability were satisfactory. Thirty-five percent of the alert notifications were due to the infusion stoppage. Furthermore, it was noted that alerts were also generated during patient movement including postural changes or attendance to the ward toilets. The results of this study suggest that the drip rate monitoring system can support nurses with infusion management when the infusion rate continues at over 150 mL/h, or less than 5 mL/h for three minutes. However, challenges remain, such as the need to expand the alert notification's operating range.

Key words: over-infusions, drip rate monitoring system, usage, specifications

INTRODUCTION

In nursing work, incidents related to manual drip adjustments for intravenous (IV) management are not uncommon.^[1] These incidents include both over- and under-infusion. Specific examples include the accidental, rapid infusion of albumin solutions or anticancer drugs. There are also cases where the infusion was unintentionally paused, resulting in the prescribed fluids not being administered.^[2] Factors contributing to these incidents include insufficient checks, lack of knowledge and/or skills, and environmental factors such as night shifts or heavy workloads.^[3-6] Preventive measures, such as enhancing education and training or utilizing information and communications technology (ICT), have been previously proposed to prevent errors.^[7–9]

At Hospital A, over- and under-infusion incidents have also occurred. Hospital A is an acute care hospital in Tokyo with approximately 600 beds. A previous study was proposed using infusion speed adjustment aids as a preventive measure.^[10] While Hospital A typically uses infusion pumps for IV administration, there are limitations, such as the number of available pumps and the need to select which patients can use them due to the equipment's weight. Additionally, due to the lack of communication between the pump alarms and the nurse call system, there are still issues with alerts in the case

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where infusion pumps are utilized. This study aimed to evaluate the drip rate monitoring system (Tritech, Inc.)^[11] as an alternative to infusion pumps to prevent incorrect infusion rates and identify both the benefits and challenges of implementing this system in clinical settings.

METHODS

The drip rate monitoring system monitors the drip rate and sends an alert to the nurse caller if deviations from the preset rate occur. Unlike infusion pumps, the drip rate is not adjusted. To assess the system performance in a clinical setting, a questionnaire survey was conducted.

Drip infusion rate monitoring system

The drip rate monitoring system comprises of two devices: a sensor attached to the infusion tube of the infusion line and a receiver called a nurse call gateway. To use the system, the receiver is plugged into an electrical outlet and the sensor attachment point on the nurse call and the sensor is attached to the drip tube (Figure 1). The drip is adjusted manually. An alert is sent out 3 minutes after the drip is detected. The sensor sends information to the nurse call on five different occasions:

- when the infusion rate is 150 mL/h or higher due to over-infusion;

- when the infusion rate remains below 5 mL/h for 3 minutes due to the infusion stopping;

- when the sensor and the receiver are more than three meters apart due to a transmission error;

- when the remaining battery power reaches 30 minutes and

- when a sensor error occurs.

The alert flow rate for excess infusion and infusion stoppage was defined by the hospital.

The alert information is transmitted by the sensor unit in the event of any excess and an alarm is triggered. The alert name is shown on the receiver unit and the nurse call unit shows the same sound and display as the bed release sensor.

Clinical setting evaluation

To evaluate the drip rate monitoring system in a clinical setting, the targeted participants were patients confined to their own rooms who had previously received manual drip infusions. The objective was to assess the system with 100 such cases and the trial was deemed complete when each nurse had initiated at least three installations. The study included 24 ward nurses. The survey period extended from April 19, 2023 until all eligible nurses had responded and was conducted anonymously using Microsoft Forms.

The survey addressed seven items related to the usability and specifications of the drip rate monitoring system (Table 1). Regarding the alert transmission, eight items evaluated the causes and utilization of the alerts (Table 2).

Survey methods

The survey used descriptive statistics for each item. Free-response items were categorized according to the specific survey questions.

RESULTS

The drip rate monitoring system was deployed in 76 instances where each nurse set up and started the system in at least three cases over a 49-day period from February 1 to March 21, 2023. The questionnaire response rate was 100%, with responses received from all 24 targeted nurses.

Usability and specifications of the drip rate monitoring system

Positive feedback was received regarding "Size" from all 24 respondents (100%), "Weight" and "Durability" from 23 (96%) and "Method of Installing Components" from 22 (92%) (Figure 2).

Transmission of alert information

During the survey period, 154 alerts were sent out (Figure 3).

The causes of the alerts included 54 cases (35%) of infusion stoppage, 52 cases (34%) of over-infusion and 32 cases (21%) of transmission errors (Table 3 and Figure 4).

Conditions for sending alert information

"Lag" and "reminder time" were selected by 22 respondents (92%), The "Infusion Stop Alert Alerting Lag" and "Reminder Alerting Time" were selected by 22 respondents (92%) and "Infusion Stop Alerting Flow Rate" by 19 respondents (79%) (Figure 5).

DISCUSSION

No concerns regarding the usability of the drip rate monitoring system were expressed and the current specifications were deemed satisfactory. The most frequent triggers for the transmission of alerts were infusion stops and over-infusions. Consequently, it is assessed that the drip rate monitoring system can

Table 1: Survey items regarding the usability and specifications of the drip rate monitoring system

Ease of viewing screen
Weight
Durability
Installation of components

Ease of use Size Sensor activation (lighting/flashing)

Table 2: Survey items related to the alert transmission of the drip rate monitoring system

Factors	
Specifications	
Infusion stop alert	Over-infusion alert
Communication error alert	Sensor failure alert
Battery level alert	Nurse call display
Reminder firing time	Drip infusion rate confirmation time

Table 3: Free description of the factors triggering the transmission of alerts

Infusion stop alert

End of infusion, change in patient's condition, infusion stopped

Over-infusion alert

Patient's posture change, drip adjustment, overdose, unstable rate

Transmission error alert

Transfer out of patient's room, transfer to indoor toilet

Sensor error alert

Inappropriate removal

Low battery alert



Figure 1. Outline of the drip rate monitoring system.



Appropriate 🔲 Slightly appropriate 💷 Not so appropriate 🗆 Not appropriate 🗆 Other

Figure 2. Usage and specifications of the drip rate monitoring system.











Figure 5. Conditions for sending alert information.

effectively support nursing staff in managing infusions when the rate exceeds 150 mL/h or drops below 5 mL/ h for a duration of 3 minutes. However, under the current system, the reasons for alerts are not known until a nurse visits the patient's room. With this in mind, future enhancements could include displaying the alert causes directly on the nurse call system for immediate

clarification.

Moreover, the primary reasons cited for transmission errors were movements outside the patient's room and to the bathroom within the room. Furthermore, 14 respondents (58%) cited inadequate "transmission error reporting distance", attributing this to the system's operational range being limited to three meters from the receiver. Expanding this range will require the development of new specifications to accommodate broader coverage.

We believe that the IV drip rate monitoring system is useful for countermeasures against over- and underdosing in manual infusion. To ensure the system can be used in clinical practice, a mechanism to understand the system's operating range and the reason for sending alert information must be developed.

DECLARATIONS

Author contributions

Shuko Muraoka conceived the study. Shuko Muraoka and Hazuki Matsuo developed the theoretical framework and performed the experiments. Takao Orii supervised the project. All authors discussed the results and contributed to the final manuscript.

Conflicts of interest

The authors have no conflicts of interest to disclose.

Data sharing statement

No additional data is available.

REFERENCES

- Miura N, Manabe M, Ichida K, Tajima M, Takeuchi F, Yajima T. et al. Analysis of incident reports: focusing on factors related to injection incidents. Bulletin of Kawasaki City College of Nursing 2002;7(1):9-16.
- Ministry of Health, Labour, and Welfare. Juuyou jirei shuukei kekka [Results of Tabulation of Important Incidents]. Ministry of Health, Labour and Welfare. [accessed on April 26, 2024] Available from: https://www.mhlw.go.jp/topics/bukyoku/isei/i-anzen/1/syukei4/9a. html
- Haruko Kawamura. Hiyari Hatto 11,000 Jirei niyoru era mappu kanzenbon [Error Map Complete Guide Through 11,000 Minor Incidents]. Tokyo: Igaku Shoin, 2003.
- 4. Kaneko. Yueki misu ni taisuru risuku manejimento, igaku no ayumi bessatsukan iryou risuku manejimento ni mukete [Risk management against drip errors, Path of Medicine separate volume Towards Medical Risk Mangement]. Ishiyaku Shuppan Kabushiki Gaisha, 2003
- Shinobu Murashima, Masae Nagafuji, Kiyomi Tsu. Yueki sokudo kanri ni okeru era no youin bunseki—toubyoutou no H16 17 nendo no inshidento akushidento hassei joukyou houkokusho wo mochiite [Analysis of factors contributing to errors in drip speed management—using the 2004/2005 incident/accident report from our ward]. Nara Univ Hosp J 2003;38.
- Rika Yatsushiro, Yuko Matsunari, Masayuki Kakehashi. Kango shoku ni okeru "Yoyaku era hassei" ni kakawaru youin—kokunaigai no kenkyu

doukou to kongo no kadai [Factors relating to medication error in nursing professionals—Research trend domestically and internationally and problems for the future]. Jpn Occup/Disaster Med Conference J 2004

- Ryutaro Kawano. Hyu-man era hassei no mekanizumu to sono boushisaku [Mechanisms of human errors and its prevention]. Jpn Dial Med J 2004
- Chiharu Matsumoto. Development and evaluation of the infusion management system by ICT utilization. 20th Japan Medical Information Conference Nursing Study Research Paper Collection, 2019
- 9. Yuichiro Okada, Tamami Suzuki. Yueki sokudo no chouka boushi wo

mezashite—daburu kurikku wo mochiita yueki sokudo kanri no yuyousei [To prevent overinfusion of drips—The efficacy of managing drip speed with double clips]. Nurs Mag 2005

- 10. Muraoka S, Yamato T, Yukimori M, Iwahara Y, Tanaka S, Fujitomi T, et al. Analysis of background factors of near-miss cases regarding infusion administration speed, focusing on cases of too fast administration speed, 47th Annual Meeting of the Japanese Society of Nursing Science, Abstracts of Nursing Management 2016;417.
- Tritec Corporation HP. [accessed on April 26, 2024] Available from: http://www.tri-tech.co.jp/dripnavi/dripnavi01/