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Research Article

Identifying Barriers to the Utilization of Intravenous Pump-System Safety Software

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Abstract

Purpose: Smart infusion pump systems such as the BD Alaris™ Guardrails™ Safety Software (AGSS) aim to decrease medication errors. In 2020, the Institute for Safe Medical Practices (ISMP) set a goal compliance rate of ≥ 95% for utilizing smart pump programs. At the start of this study, the average monthly compliance rate at University Medical Center New Orleans (UMCNO) was 78%. The purpose of this study was to identify barriers to compliance with the AGSS. **Methods:** This was a single-center, cross-sectional study of practicing nurses at UMCNO. From August 9 to October 14, 2022, an electronic survey was distributed to all nursing staff about the AGSS. The primary endpoint was to identify potential barriers affecting the utilization of AGSS. The secondary endpoints were to identify unit-specific trends and barriers to compliance. **Results:** A total of 152 responses were analyzed includedin the study. Analysis of primary endpoints revealed 24.8% of respondents had not received or were unsure of their last formal training for the AGSS. Another 24.3% of respondents had not been formally trained on the AGSS in over one year. Maintenance fluids were the most overridden medication, occurring 40% of the time. **Conclusion:** This study highlights potential barriers to using the AGSS, primarily in terms of education and training. Moving forward, plans are in place to implement annual training, monthly reviews on bypassed Guardrails, and interoperability between the Alaris™ system and electronic health records. Future surveys are necessary to assess if these implementations are effective in increasing compliance.

Keywords: Safety; Medication errors; Nursing; Infusion pumps; Surveys and Questionnaires; Compliance

In the US, 7,000 to 9,000 patients die each year due to medication errors [1]. More than 50% of serious and life-threatening medication errors are due to intravenous (IV) medications [2]. Smart infusion pumps with dose error-reduction systems (DERS), such as the BD Alaris™ Guardrails™ Safety Software (AGSS), along with associated drug libraries are utilized to decrease IV medication errors [3]. One of the primary safety features of DERS is drug libraries as well as hard and soft rate limits. Drug libraries are a set of pre-programmed lists of medications, set by the institution, for specific patient care areas. The goal of having drug libraries is to minimize the amount of irrelevant medications to decrease the chances of medication errors. Hard limits are rates that cannot be bypassed and prevent excessive rates from being initiated. Soft limits warn the user that the rate is outside the expected range but still allow the infusion to start as programmed. All Guardrail limits may be bypassed altogether using the basic infusion mode.

In 2020, the Institute for Safe Medical Practices (ISMP) set a compliance rate goal of ≥95% for using dose error-reduction systems [4]. The ISMP conducted two surveys on the use of smart infusion pumps as well as challenges for implementation [5]. The first survey found that the most common errors in using the smart pump were secondary infusions delayed/omitted due

to roller clamps being closed, dose-rate confusion during pump programming, wrong rate errors for secondary infusions, and IV line or channel mix-ups [6] The second survey questioned only front-line nurses and their errors were similar to the previous survey [7]. The most common errors were the secondary infusion being delayed/omitted due to the roller clamp being closed, dose-rate confusion, and wrong rate errors for secondary infusions.

Williams I. conducted a pre- vs post-survey on the use of the AGSS after several organization-wide interventions. The interventions include smart pump training at orientation, updating drug libraries quarterly, a pump champion program, and continuous monitoring. This study showed an increased rate of compliance after the interventions, 63% to 88%, and a decrease in medication errors, 1108 events to 235 events. These interventions were successful in increasing the compliance rate, however, they were not at the ISMP goal of ≥95% compliance. Several barriers they remained post-intervention were that the drug was not found in the Guardrails TM library, the nurse did not have enough time to use the Guardrails ™ /the Guardrails ™ is tedious, and existing Guardrails ™ settings do not match with workflows in their care areas.

University Medical Center New Orleans (UMCNO) has set a benchmark of 90% compliance rates for the utilization of Guardrails™. Currently across all units at UMCNO, the average monthly compliance rate is 78%. The purpose of this study was to identify barriers to the use of Guardrails™ among nursing staff with the future goal of implementing future changes to increase compliance across all units.

Methods

All fourteen survey questions were developed with the intent to broadly target potential factors that may influence a nurse's decision when deciding to operate outside of AGSS. Questions were also designed to capture the years of experience as an RN and tenure at UMCNO. After the questions were developed, a screening process was undertaken to validate the survey questions' applicability to a registered nurse's workflow. Questions were first screened by the UMCNO Department of Pharmacy research committee, followed by nursing leadership from planned participating units. The pharmacy research committee and nursing unit leaders were given the opportunity to screen prospective questions and provide feedback prior to the Institutional Review Board (IRB).

This was a single-center, institutional-based cross-sectional study of all nursing staff at UMCNO. The site is a 446-bed, safety-net, research, and academic hospital. This study was approved by the IRB-Louisiana State University Health Sciences Center as well as by the UMCNO Office of Research (states Research Office). From August 9, 2022, to October 14, 2022, an electronic survey was distributed to all nursing staff about their utilization and potential barriers to the AGSS. Nurses either scanned a Quick Response (QR) code or entered a link to a survey on Microsoft Forms, where they entered anonymous responses. Included in the survey were nurses who worked at UMCNO. Those that were excluded from the survey were nurses who only worked in the Emergency Department (ED) as well as nursing students and certified nursing assistants. Nurses who only worked in the ED were excluded because of the high rate of bypassing the Guardrails™ due to emergent scenarios. If a nurse worked in the ED as well as another unit (e.g. ED + medical floor), they would be included.

Survey

An electronic, 14-question survey was distributed to all nursing staff. The survey was distributed by handouts and e-mail. Nurses accessed the survey by scanning a quick response (QR) code or entering the link to Microsoft Forms. The analyzed responses were categorized into 3 units, intensive care unit (ICU), general floor, and procedural areas. The intensive care unit consisted of the burn ICU, medical ICU, and trauma ICU. The general floor consisted of the medical/surgical floors, the observational unit, and the controlled access unit (prison unit). The procedural areas consisted of the inpatient oncology, operating room, outpatient infusion, outpatient oncology, outpatient surgery, and post-anesthesia care unit (PACU).

The electronic survey was categorized into 2 major groups. Questions 1-5 are baseline characteristics looking at nursing credentials, total years practiced, years practiced at UMCNO, employment status, and unit assignment. Questions 6-14 aim at identifying barriers to the AGSS and are further divided into subgroups. Questions 6 and 7 assess the nurse's background knowledge and education on the AGSS. Questions 8-9 asses the nurse's response and reason for using the basic infusion mode. Questions 10-11 assess communication between nurses.

Questions 12 - 14 assess programming barriers.

Endpoints

The primary endpoint was to identify potential barriers affecting the utilization of Alaris™ Guardrails™ Safety Software. The secondary endpoints were to identify unit-specific trends of compliance non-compliance and barriers to utilization. For the unit-specific trends, only the ICUs and general floor were included in the secondary analysis. Responses from the procedural areas group were excluded from unit-specific trends due to differing practice patterns with the use of the AGSS. Results from the primary and secondary endpoints were analyzed using descriptive statistics.

Results

Study Participants

From August 9, 2022, to October 14, 2022, 157 survey responses were collected. Of the collected responses, a total of 152 responses were assessed with the other five responses being excluded due to the participants only working in the emergency department. The majority of staff nurses were credentialed as "registered nurses" (90.8%), with a total of 1-5 years of practice experience in both total years (40.1%) as well as years at UMCNO (48%). In terms of employment status at UCMNO, the majority of participants worked full-time (71.1%). Part-time employees made up 15.1% of responses and contract employees made up 13.2%. For survey responses, there was a comparable number of responses amongst the general floor (44.1%), ICU (37.9%), and "other" units (18%). Of note, there were no reported survey responses from several areas such as outpatient infusion, outpatient oncology, and outpatient surgery.

Baseline characteristics	
Variable	Frequency (%)
1. My nursing credential is:	
Licensed Practical Nurse (LPN)	9 (5.9)
Registered Nurse (RN)	138 (90.8)
APRN (Advanced Practice Registered Nurse)	5 (3.3)
2. I have been practicing for:	
0-1 years	20 (13.2)
1-5 years	61 (40.1)
5-10 years	33 (21.7)
>10 years	38 (25.0)
3. I have worked at University Medical Center New Orleans (UMCNO) for:	
0-1 years	35 (23.0)
1-5 years	73 (48.0)
5-10 years	33 (21.7)
>10 years	11 (7.2)
4. My current employment status is:	
Full-time	108 (71.1)
Part-time/PRN	23 (15.1)
Contract	20 (13.2)
Other	1 (0.7)
5. Which unit(s) do you currently work in? (Select all that apply)	
Floor	71 (44.1)
Medical/Surgical Floor	55 (34.2)
Observation Unit	11 (6.8)
Controlled Access Unit	5 (3.1)
ICU	61 (37.9)
Trauma	35 (21.7)
Medical	14 (8.7)
Burn	12 (7.5)
Others	29 (18)
Emergency Department	2 (1.2)
Inpatient Oncology	5 (3.1)
Operating Room	4 (2.5)
Outpatient Infusion	0
Outpatient Oncology	0
Outpatient Surgery	0
Post-anesthesia care unit (PACU)	16 (9.9)
Respiratory*	1 (0.6)
IHP*	1 (0.6)
*These responses were imputed by the respondent	

Survey Responses

Background knowledge and education

Most nurses knew the difference between the Guardrails ™ mode and the basic infusion mode (83.6%). In terms of the last formal training, 24.8% of respondents had not received or were unsure of their last training session for the AGSS and 24.3% of respondents had not been formally trained in over one year.

Response for using the Basic Infusion mode.

If a nurse cannot find a medication in the drug library, the top responses were that they would utilize the Basic Infusion mode and notify the pharmacy (34.5%), ask another nurse for assistance (31.8%), or contact the pharmacy for assistance before choosing the Basic Infusion mode (27.8%). Most nurses claimed to have bypassed the AGSS in the past year, with less than half never bypassing the Guardrails™ mode and using the basic infusion mode (40.8%).

Communication between nurses

The majority of respondents answered that they always tell the oncoming nurse when the Basic Infusion mode is being utilized (51.3%). On the contrary, most nurses said that they have never been informed if the Basic Infusion mode is being used at shift change (61.8%).

Possible programming barriers

The most common reason for a nurse to override the AGSS was being unable to find the medication in the drug library (27%) followed by the ordered rate being above or below the soft limits (21.5%). The most common overridden medication was maintenance fluids (39.8%). A majority of respondents never had the drug library loaded incorrectly in the past year (52.6%).

Unit-specific trends

Comparing the differences between the medical floor and the ICUs, in terms of bypassing the AGSS in the past year and using the Basic Infusion mode, the largest proportion of nurses on the medical floors said they have never done so (49.2%), whereas the most common response for nurses in the ICU have done it less than once a month (42.9%). In terms of reasons for overrides, the most common reason on the floor was that the medication was not in the drug library (27.8%), but in the ICU it is that thetitration rate was not above or below the soft limits (29.8%). The most common medication to override in both the Floor and ICU were maintenance fluids, 49.4% and 32.6% respectively. The second most common medication to override in the floor units was nonformulary medications (17.3%) and in the ICU was fluid resuscitation (17.9%).

Results			
Variable	Frequency (%)		
	Total (N=152)	Floor (n=65)	ICU (n=56)
6. I know the difference between the Alaris™ System Guardrails™ mode and the Basic Infusion mode on the Alaris™ pump.			
Yes	127 (83.6)	53 (81.5)	47 (83.9)
No	7 (4.6)	3 (4.6)	2 (3.6)
Unsure	18 (11.8)	9 (13.8)	7 (12.5)
7. I last received formal training or education on utilizing the Alaris™ System Guardrails™ at UMCNO:			
< 6 months	55 (36.2)	24 (36.9)	25 (44.6)
6-12 months	20 (13.2)	12 (18.5)	6 (10.7)
1-5 years	27 (17.7)	9 (13.8)	10 (17.9)
>5 years	11 (7.2)	5 (7.7)	3 (5.4)
Never/Unsure	39 (25.7)	15 (23.1)	12 (21.4)
8. If I cannot find a medication in the drug library, I: (Select all that apply)			
Utilize basic infusion and notify the pharmacy	76 (34.5)	34 (35.8)	28 (35)
Ask another nurse	70 (31.8)	29 (30.5)	26 (32.5)
Contact pharmacy	61 (27.8)	28 (29.5)	21 (26.3)
Utilize basic infusion without notifying pharmacy	8 (3.6)	2 (2.1)	4 (5)
None/Never	4 (1.8)	1 (1.1)	1 (1.3)
Other	1 (0.5)	1 (1.1)	0
9. In the past year, I have bypassed the Alaris™ System Guardrails™ and used the basic infusion mode:			
Never	65 (40.8)	32 (49.2)	18 (32.1)
Less than once a month	47 (30.9)	16 (24.6)	24 (42.9)
Once a month	24 (15.8)	10 (15.4)	11 (19.6)
Once a week	11 (7.2)	6 (9.2)	2 (3.6)

Once a shift	3 (2)	0	0
More than once a shift	2 (1.3)	1 (1.5)	1 (1.8)
10. In the past year, if I am utilizing the Basic Infusion mode, I inform the oncoming nurse at shift change:			
Always	78 (51.3)	31 (47.7)	28 (50)
Sometimes	21 (13.8)	11 (16.9)	7 (12.5)
Never	53 (34.9)	23 (35.4)	21 (37.5)
11. In the past year, the previous nurse informed me that a medication was running under the Basic Infusion mode:			
Always	22 (14.5)	8 (12.3)	7 (12.5)
Sometimes	36 (23.7)	14 (21.5)	15 (26.8)
Never	94 (61.8)	43 (66.2)	34 (60.7)
12. In the past year, if I have overridden the Alaris™ System Guardrails™ library soft stops or used the basic infusion mode for the following reason(s): (Select all that apply)			
The medication was not in the drug library	64 (27)	25 (27.8)	28 (26.9)
The titration rate was above/below the soft limits	51 (21.5)	16 (17.8)	31 (29.8)
Basic infusion mode was used for continuous infusions, boluses, or flushes	39 (16.5)	20 (22.2)	14 (13.5)
Emergent scenario	30 (12.7)	2 (2.2)	20 (19.2)
Basic infusion saves time	5 (2.1)	2 (2.2)	2 (1.9)
Unsure how to use the Guardrails	1 (0.4)	2 (2.2)	0
I have never overridden the guardrail limits	45 (19)	23 (25.6)	9 (8.7)
Other “Patient weight not calculated” “Correct concentration not available”	2 (0.8)	0	0
13. The types of medication I have overridden the Alaris™ System Guardrails™ or used the Basic Infusion mode are: (Select all that apply)			
Maintenance fluid	92 (39.8)	40 (49.4)	31 (32.6)
Fluid resuscitation	31 (13.4)	3 (3.7)	17 (17.9)
Nonformulary	24 (10.4)	14 (17.3)	4 (4.2)
Antibiotics	23 (10)	12 (14.8)	9 (9.5)
Blood products	19 (8.2)	6 (7.4)	11 (11.6)
Vasopressor	8 (3.5)	1 (1.2)	5 (5.3)
Sedatives	7 (3)	0	6 (6.3)
Total parenteral nutrition	6 (2.6)	3 (3.7)	2 (2.1)
Analgesia	4 (1.7)	0	0
Antihypertensives	3 (1.3)	0	1 (1.1)
Copper products	3 (1.3)	0	3 (3.2)
Gastrointestinal ulcer prophylaxis	2 (0.9)	0	1 (1.1)
Anticoagulants	2 (0.9)	1 (1.2)	1 (1.1)
Others*	4 (1.7)	0	3 (3.2)
Unsure	3 (1.3)	1 (1.2)	1 (1.1)

14. In the past year, how many times has the incorrect Alaris™ System Guardrails™ drug library profile been loaded onto your patient's Alaris™ pump system? (e.g. Adult Critical Care profile for an Acute Medicine Unit patient instead of Adult Med/Surg profile)			
Never	80 (52.6)	37 (56.9)	29 (51.8)
Once	9 (5.9)	5 (7.7)	3 (5.4)
2-5 times	21 (13.8)	8 (12.3)	7 (12.5)
>5 times	8 (5.3)	4 (6.2)	3 (5.4)
Unsure	34 (22.4)	11 (16.9)	14 (25)

Discussion

A barrier to the use of the AGSS identified in this study was education. About a quarter of respondents claimed to either have never been formally trained or are unsure of their last formal training on the AGSS. Assessing the training practices at UMCNO, it was discovered that all nurses are trained on the AGSS during orientation, however, only nurses in the ICU receive annual training. Future training events or modules are planned with nursing instructors.

The most common medication that was overridden was maintenance fluids. After reviewing the AGSS, the process to run maintenance fluids is in a different section than medications. Maintenance fluids are under the "IVF Guardrails" whereas all other drugs are under "Drug Guardrails." For example, a nurse could try to look for the fluids in the Drug Guardrails section, but not find it the nurse may skip over the "IVF Guardrails" library, opting for the basic infusion mode. Common maintenance fluids, such as normal saline or lactated ringers, are not listed specifically in the IVF Guardrails™ library, instead, they are encompassed under the "Maintenance IVF" selection.

Since this survey was conducted at a single center and most respondents were employed full- time they should have received the same training on the Alaris™ Guardrails™. This minimized confounding factors in terms of background training. Since this is a self-reported survey, there are some discrepancies between answers. Of note, the most common reason for bypassing the Guardrails™ was that the medication was not in the drug library. However, the most common medication that was overridden was maintenance fluids, which are available in all AGSS in their own section of IV fluids.

Another discrepancy is in questions 11 and 12. Most nurses stated that they always tell the oncoming nurse that the basic infusion mode is running, yet most nurses stated that they are never notified that the basic infusion mode is being used. A limitation was the lack of responses from certain units. There were no responses from outpatient infusion, outpatient surgery, or outpatient oncology even though the survey was disseminated in person at least once and received the survey via electronic mail. Several actionable items have been identified by pharmacy and nursing that will increase compliance. The first is annual training on the AGSS. All nurses have received training during orientation. However, since the Guardrails™ drug library is updated regularly, annual training would assist the nurses in using the AGSS.

The second actionable item is the interoperability between the Alaris™ system and the electronic health record. Currently, there is no communication between what is being electronically ordered and the pump system. Pharmacy personnel are currently working on implementing a possible barcode system so that the nurse would not have to manually input the order into the smart pump, decreasing the time to administer drugs and steps for possible medication errors. The drug libraries currently are reviewed at least quarterly and compliance rates between units are reviewed monthly. This practice will continue moving forward. After these implementations, a future survey would be used to assess any further barriers. In future surveys, the inclusion of a comment question would also be useful in gaining more perspectives on the respondent's thoughts.

Conclusion

This pharmacy-driven survey of nurses provides valuable insight into the current usage of the AGSS and explains why UMCNO is neither achieving its internal nor ISMP's goal rates of compliance. The primary barrier identified was the lack of education on the AGSS. Annual nursing education, interoperability between smart pumps and electronic health records, and regular reviews of the AGSS are being implemented to improve compliance rates. Future studies are necessary to assess the effectiveness of these interventions.

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