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Barriers to the Use of Guardrails On IV Smart Pumps

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by

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DEDICATION

I would first like to dedicate this dissertation to the Almighty God! I also dedicate this thesis to the late Mr. Allen Cleveland, my grandfather, for your influential love in always trusting the universe's declarations telling you that I would be a successful healthcare leader someday. This dissertation is also dedicated to my grandmother, the late Mrs. Helen Cleveland, my parents, Mr. and Mrs. Archie and Juanita Thomas, my brother, Mr. Antoine C. Williams, my three children, Brian, Topaz, and Romyn, my cousins, my aunts, my uncles, and my friends. This work was completed thanks to the humility, love, and appreciation I have cultivated through each of you along my journey.

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ABSTRACT

Medication errors involving hospitalized patients have been an evolving challenge for decades. Moreover, errors related to intravenous (IV) medication administration continue to rise in hospitals despite implemented policies governing the use of Guardrails™ for safe IV medication infusion via smart pump technology. An organizational investigation was performed to identify barriers to the use of Guardrails™ among nursing staff. From 2015 through 2017, multiple interventions that aimed to identify barriers and increase nurses' use of the safety features on IV smart pumps were implemented in the hopes of reaching a compliance goal of 90-100%. This quality improvement project assesses Guardrails™ compliance with smart pumps since its initial integration in 2010 and through 2017. A systematic organizational assessment was conducted at a Magnet®-recognized facility in South Carolina to identify the factors that influence the use of Guardrails™ by nurses, implement changes based on the assessment, measure outcomes, and make recommendations for future change to foster continued progress towards the 90-100% benchmark. Participants included all nurses who utilized the smart pumps with Guardrails™ (*N*=2,500). The results provided insights into the factors that either succeeded or not through collaboration with numerous stakeholders, metrics on Guardrails™ utilization, self-reported IV medication errors per year, and a pre- and post-project survey. The project offered valuable information that was used to implement changes that eventually resulted in an increase in nurses' compliance with Guardrails™ use, provided recommendations for sustaining compliance, and proposed

updates to the facility's IV medication administration policy. The data results from the Guardrails™ compliance report and IV medication error rate between 2015 and 2017 provided enough evidence to suggest that a structured continuous education plan is essential to increase nurses' awareness and adherence to policies and procedures governing the use of Guardrails™ on IV smart pumps.

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LIST OF SYMBOLS

$>$ Greater than.

N Number of total population.

n Number of sub-population.

$<$ Less than.

z Standard score on a normal distribution curve.

p Probability value.

t Standard score on a normal distribution curve.

® Trademark registered.

™ Trademark.

LIST OF ABBREVIATIONS

ACNO .... Assistant Chief Nursing Officer

AGAC .... Alaris Guardrails™ Audit Champion

AGT .... Alaris Guardrails™ Team

AAMI .... Association for the Advancement of Medical Instrumentation

BSN .... Bachelors of Science in Nursing

C .... Critical Care

CC .... Critical Care

CQI .... Continuous Quality Initiatives

CQP .... Continued Quality Programs

E .... Education

EBP .... Evidence-Based Practice

ED .... Emergency Department

EHR .... Electronical Health Record

FDA .... Food and Drug Administration

GI .... Gastroenterology

I .... Infusion Cancer Center

ICU .... Intensive Care Unit

ID .... Identifier

ISMP .... Institute for Safe Medication Practices

IV .... Intravenous

LPN .... License Practical Nurse

M .... Meduflex Floating Pool

MAT...Medication Administration Team

ME... Medication Errors

MS...Medical/Surgical Floors

OC..Organizational Culture

PACU... Post Anesthesia Care Unit

P ....Pediatrics

PICOT .... Population-Intervention-Comparison-Outcome-Timing

PIDC .... Parental Infusion Device Coordinator

PRN..As Needed

PSI... Patient Safety Net

S .... Specialty Areas

SD ....Standard Deviation

SPC .... Smart Pump Champions

SPESM..Smart Pump Evaluation and Surveillance Methods

US ....United States

CHAPTER I

INTRODUCTION

Medical errors account for 10% of deaths in the United States (U.S.) every year and have now been rated as the third leading cause of death in the U.S. (Sternberg, 2016). Medication errors are part of this horrible statistic. One approach to reducing intravenous (IV) medication errors is the use of smart pump technology (Association for the Advancement of Medical Instrumentation [AAMI] and the Healthcare Technology Safety Institute, 2014). The purpose of this quality improvement project was to conduct a systematic organizational assessment to identify factors that influence use of Guardrails™ safety features by nurses, implement changes based on the assessment, measure outcomes, and make recommendations for change. Chapter I provides a description of the clinical problem, scope of the problem, clinical environment, analysis of clinical problem, the evidence-based practice (EBP) question and the population-intervention-comparison-outcome-time (PICOT) definitions, and assumptions.

Description of the Clinical Problem

In the 1990s, smart IV pump technology began to be used in hospital-specific areas (Vanderveen, 2014). IV smart pumps were designed to help prevent IV medication errors (Gavriloff, 2012). However, human mistakes continued to occur, directly affecting patient safety (Institute for Safe Medication Practice [ISMP], 2013). In 2008, the facility decided to adopt the newly innovative IV smart pump technology in an effort to increase IV medication safety and improve patient outcomes. In 2010, the facility noticed a significant increase in IV medication errors with 978 IV medication errors. The facility contacted the makers of the Alaris® IV smart pumps (e.g. CareFusion®) and implemented Guardrails™ safety features into the IV smart pump's drug libraries in April of 2010. The Guardrails™ safety features were added to the IV smart pumps to prevent IV medication errors. The hospital set a goal that nurses would use the smart pump and Guardrails™ safety features 90-100% of the time. Despite implementing Guardrails™ safety features, metrics on IV medication errors and Guardrails™ utilization were below benchmark, as compliance data revealed that nurses used Guardrails less than 75% of the time. Also, there were approximately 1,000 cases of IV medication errors reported between 2011 through 2016. Nurses were not using the Guardrails™ safety features on IV smart pumps. The question is “why?”

Scope of Problem

A number of authors have identified the problem of use of Guardrails™ safety features by nurses. Gavriloff (2012) found that nurses used medication safety software properly 28% of the time. In addition, Gavriloff (2012) provided evidence that, with effective education strategies, staff adherence rates went from 28% to 85% within a week. However, education did not prevent errors unless the software was programed properly and nurses used the features (Gavriloff, 2012). Sullivan and Palillo (2014) identified that of 5780 intensive care units (ICUs) IV smart pump alarms, 7% were referencing dose corrections. They concluded that nurses lacked understanding of IV smart pump technology that may potentially be influenced by their perceptions, which led to incorrect modification of the pump. Rosenkoetter, Bowcutt, Khasanshina, Chernecky, and Wall (2008) came to the same conclusion. Perceptions played a large part in the implementation of new technology in hospitals. Harding (2012) called for better understanding of how nurses use smart pumps and noted that a distinct culture of non-compliance existed in hospitals that required rigorous monitoring and education. Harding (2012) concluded that the problem may be due to nurses' lack of understanding of the features on smart pumps, hospital policy and procedures related to smart pumps, or failure to acknowledge the legal jeopardy when bypassing the IV smart pump drug libraries. If patient harm occurs as a result of nurse's non-compliance with smart pump technology, the nurse could be at fault in court proceedings (Harding, 2012). In a study conducted by Westbrook, Rob, Woods, and Parry (2011), findings revealed that of 101 serious IV administration errors, 95 errors resulted from the use of the wrong IV rate. The authors identified that routine violations with the use of IV smart pumps stemmed from behaviors learned in the workplace (Westbrook, Rob, Woods, & Parry, 2011).

Alaris® IV smart pumps for the administration of IV medications were initiated in the facility in 2008. Two years later, the instances of IV medication errors remained high prompting the facility to enhance the smart pumps by upgrading their Guardrails™ safety features in 2010 to increase patient safety. Guardrails™ is "a hospital-defined list of drugs and concentrations appropriate for use in as many as 15 profiles" (Alaris®Guardrails, 2016, p.1). The quality assurance data reported on all self-reported IV medication errors and near misses at the facility remained at an all-time high from 2010 through 2015. In 2011, there were approximately 1500 documented cases of self-reported IV medication errors within the facility. Also, errors related to IV medication administration cost the facility millions of dollars. For example, the facility paid $3.8 million to five families for injuries that resulted from medication errors (Monk, 2002).

The AAMI (2014) postulated that planning ahead and creating an effective plan to monitor compliance was highly recommended before integrating systems of infusion pumps. Unfortunately, the facility did not establish an effective plan to monitor compliance data before smart pumps and Guardrails™ were introduced. In January of 2015, a hospital-wide electronic survey was sent to all nurses who administered IV medications to determine barriers to use of smart pumps with Guardrails™. In March of the same year, the Alaris Guardrails™ Team (AGT) was formed and consisted of two nurse managers, a pharmacist, a performance improvement facilitator, a critical care staff nurse who joined the team in March of 2016, and two nursing patient facilitators who recently joined the team in September of 2016. Their charge was to use the data from the survey to identify barriers to the use of smart pumps and Guardrails™ drug libraries by nurses and implement needed changes.

Clinical Environment

The project will took place at one of only three Magnet® recognized institutions in South Carolina. The institution is a 700-bed academic hospital accounting for over one million patient encounters per year. There were a total of 7,000 employees, which included 750 physicians and 2,500 nurses. In addition, the institution experienced approximately 36,114 inpatient encounters and 1,205,066 outpatients encounters every year. The project included all 58 inpatient and outpatient units that utilized smart pumps with Guardrails™ safety features. There were approximately 740 licensed beds among all four hospitals managed by the facility.

Analysis of Current Practices

After analyzing practices implemented when IV smart pumps were integrated at the facility, metrics on adherence to Guardrails™ safety features revealed that nurses utilized Guardrails™ less than 75% of the time, placing the facility in the 28th percentile compared to 764 other institutions that utilized CareFusion® smart pumps technology (Dykema, 2015). The data on use of IV smart pumps with Guardrails™ features suggested that a more structured process of change was needed. This conclusion prompted the institution to develop the AGT charged with implementing interventions to increase use of Guardrails™ by nurses. The benchmark set was for nurses to use Guardrails™ 90-100% of the time.

Purpose

The purpose of this quality improvement project was to conduct a systematic organizational assessment to identify factors that influence use of Guardrails™ by nurses, implement interventions based on the assessment, measure outcomes, and make recommendations for future change in order to foster continued progress toward the benchmark set by the facility of 90-100% of the time.

Theoretical Framework

The theoretical framework used to guide this quality improvement project was adopted from Kurt Lewin's Change Management Theory in Figure 1.1 (see Appendix A).

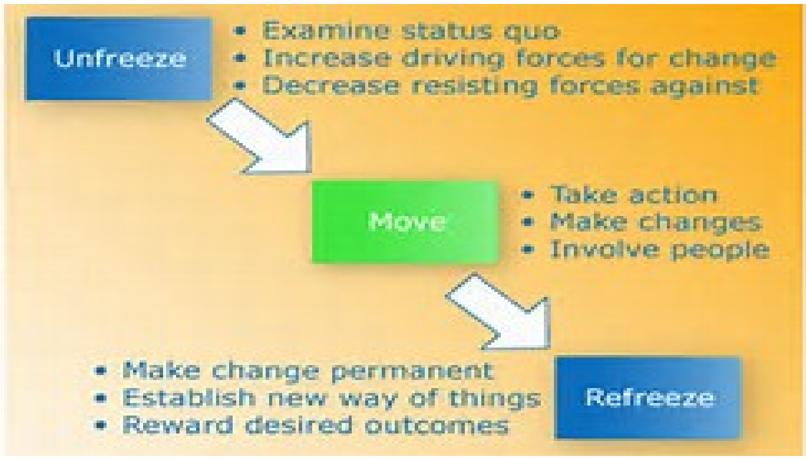

Figure 1.1 Kurt Lewin's Change Management Model

Project Questions

Prospective questions included 1) as IV smart pump's Guardrails™ compliance rate increases, does self-reported IV medication errors decrease; 2) does the number of self-reported IV medication errors decrease with implementation of each intervention, if so, what factors significantly impacted increasing compliance rates, and why; 3) according to data from the post hospital-wide survey, are there new barriers identified by staff nurses, if so, what are these barriers; and 4) does the post nursing survey report an increase in staff nurse's knowledge and awareness regarding proper utilization and adherence to IV smart pump's Guardrails™ policies and procedures.

EBP Question and PICOT Definitions

The EBP and the PICOT definitions are based on the format developed by Melnyk and Fineout-Overholt (2011). The EBP question is "For hospital based nurses using smart pumps with Guardrails™ (P), what are the factors that influence the use of smart pumps with Guardrails (I) after implementing interventions based on the 2015 systematic organizational assessment and hospital-wide survey (C) as measured by the

2017 hospital-wide systematic organizational assessment and survey, percent of use of Guardrails™ by nurses, and self-reported IV medication errors per month? The PICOT definitions are given in Table 1.1. Other definitions are stated below.

IV smart pump technology: According to the U.S. Food and Drug Administration ([FDA], 2014), an IV smart pump is technology that is "equipped with safety features, such as user-alerts that activate when there is a risk of an adverse drug interaction, or when the user sets the pump's parameters outside of specified safety limits" (para 6). Guardrails™: The Guardrails™ features may also be defined as a "drug library use (that) automates programming steps, including drug name, drug amount and diluent volume, and activates hospital-based established best practice limits" (Alaris®Guardrails, 2016, p.1). Factors: According to Harris (2017) a factor is considered "a circumstance [which] contribute(s) to a result" (para 12). For the purpose of this project, the term factors include things like interruptions and distractions which impacts or contributes to a result (Hughes & Blegen, 2008).

Table 1.1 PICOT Definitions

P-Population	**I**-Intervention	**C**-Comparison	**O**-Outcome	**T**-Time
Hospital based nurses using smart pumps with Guardrails™	Factors that influence the use of smart pumps with Guardrails™ policy and procedures	Implementing interventions based on the 2015 systematic organizational assessment and hospital-wide survey	Hospital-wide systematic organizational assessment and survey, percent of use of Guardrails™ by nurses, and self-reported IV medication errors per month	2 Years

Assumptions

This quality improvement project requires active involvement of stakeholders, nurses, pharmacy, and unit managers. The quality improvement project assumed that staff nurses will actively participate in providing feedback to the survey. In addition, the project assumed that nurses would possess commitment to proper use of the smart pumps with Guardrails™ safety features.

CHAPTER II

LITERATURE REVIEW

The AGT searched the literature to determine what others had identified as factors influencing use of Guardrails™ safety features by nurses. In addition, the AGT searched for interventions that had been implemented to increase use of Guardrails by nurses. Chapter II contains a description of the search process to include search terms and databases, synthesis of the literature, development of the interventions, barriers to implementation, and summary.

Search Process

The literature search occurred from January 15th, 2016 through March 4, 2016. CINAHL Complete, PubMed, Joanne Briggs Institute, Cochrane Library, and Google databases were used in the search process. CINAHL Complete was the first database searched.

CINAHL Complete

CINAHL Complete offered an abundance of articles while using the search terms compliance, smart pumps, and guardrails. Each of the search terms was placed in separate search boxes, independent of each other. The "text all" option was then chosen for each search term. The search option was selected and 268 articles were retrieved; however, only eight of the items were selected, as they all pertained to the EBP question. All other items were then eliminated because either the title or the article did not relate to the EBP question. The review continued with the CINAHL database and the search term quality improvement was used along with the term guardrails. Once more, the "text all" option was selected for both terms and 282 articles were recovered. Six of the articles were selected because they matched the EBP question. All others were eliminated because they were duplicates or did not pertain to the EBP question. During the search in the CINAHL database, several terms were used to narrow the search. The search terms used were usage, guardrails smart pumps, and assessment. A total of 519 articles were retrieved, but none of the articles were used because they were either duplicates or the article did not pertain to the EBP question. As the CINAHL search continued, the terms increase compliance, guardrails, and smart pumps revealed only two duplicate articles that were previously selected. Also, the terms continuous quality initiative, adherence, and smart pumps revealed only one article that did not relate to the EBP question. The terms drug library, adherence, and nurses revealed 308 articles. Eight were selected while the terms IV medication errors and smart pumps together revealed 51 articles with six selected that were in congruence with the EBP question. Finally, the terms IV medication errors, smart pumps, and Guardrails revealed several articles that included seven duplicates and others that failed to support the EBP question.

PubMed

The PubMed database revealed 103 articles using the search term of factors that influence the use of guardrails. Only 2 articles were eliminated because they were not relevant to the EBP question. The term increase guardrails utilization was then used as the search option, and 0 articles were retrieved. When the term increase IV drug library use was used, 50 articles were identified. Only 1 article matched the EBP question.

Finally, the search term increase use of guardrails revealed 51 articles of which 2 pertained to the EBP question. All others were eliminated because they did not support the project or the titles did not match the EBP question.

Joanna Briggs Institute

Joanna Briggs Institute was the third search engine used for the review. In general, the Joanna Briggs database offered the least amount of information. The first terms used in combination were IV medication errors and guardrails, which failed to recover any articles. Using the combined terms of IV smart pumps and drug libraries, with the publication type of evidence and summaries options selected in the search box, 3 articles were identified; 1 of which pertained to the EBP question while the others were not used.

Cochrane Library

The Cochrane Library only offered two articles that pertained to the EBP questions. Both articles were retrieved using the combined search terms of smart pumps and drug libraries. The terms smart pump, guardrails, nurse compliance to guardrails, and guardrail usage were also used and failed to identify any articles. After using all four databases, each article that was chosen was thoroughly reviewed, and eight articles were recovered from the reference section of randomly selected articles.

Google Search Engine

To conclude, the Google search engine was used to explore the FDA, the ISMP, and the Alaris CareFusion® websites. Overall, the search process was extensive and identified high-quality information related to the project. The inclusion and exclusion criteria is presented below offers a distinct criteria for the articles selected for the purpose of this project.

Inclusion and Exclusion Criteria

All articles were carefully reviewed for the second selection process. Descriptions and quality ratings were assigned based on the evidence evaluation tool adopted from the John Hopkins Nursing evidence-based practice model and guidelines (Dearholt and Dang, 2012). Throughout the search process, all articles that were related to the EBP question were used based on several inclusion criteria. First, articles were selected based on the number of times they had been cited and used by others in the literature. Second, all articles were chosen if they appropriately supported the EBP question. Third, articles that were greater than five years old were used only if they supported the EBP question and received high evidence ratings. Last, several articles suggested evaluating and reviewing articles that applied to observational continuous quality initiative (CQI) or time-motion studies. Exploration of the area of human factors was also mentioned in various articles as an aspect to consider when smart pumps were integrated.

Therefore, several articles on time-motion studies as they related to smart pump utilization and increasing guardrails usage were reviewed at random times throughout the search process. These articles were not included in the literature review and synthesis because they did not offer significant information to answer the EBP question. Table 2.1 summarizes the search process to include databases, search terms, number of articles retrieved, and number of articles used.

Table 2.1 Search Process

CINAHL

Search Terms	Number of Articles Retrieved	Number of Articles Used
Compliance, smart pumps, guardrails	268	8
Quality Improvement, guardrails	282	6
Best practice, infusion safety, guardrails	267	3
Usage, guardrails, smart pumps	253	0
Assessment, guardrails, smart pumps	266	0
Increase compliance, guardrails, smart pumps	2	2: duplicated articles
Continuous quality initiative, adherence, smart pumps	1	0
Drug library, adherence, nurses	308	8
IV medication errors, smart pumps	51	6
IV medication errors, smart pumps, guardrails	9	7: 7 repeated articles, others did not pertain to PICOT in question.

PubMed

Search Terms	Number of Articles Retrieved	Number of Articles Used
Factors that influence the use of guardrails	2	0
Increase guardrails utilization	0	0
Increase IV drug library use	50	1
Increase use of guardrails	51	2

Joanne Briggs

Search Terms	Number of Articles Retrieved	Number of Articles Used
IV medication errors guardrails	0	0
IV smart pumps	0	0
Smart pump; (with publication type of evidence and summaries Highlighted in search box).	3	1

Cochrane Library

Search Terms	Number of Articles Retrieved	Number of Articles Used
Smart pump drug libraries	2	2
Smart pump guardrails	0	0
Nurse compliance to guardrails	0	0
Guardrails usage	0	0

Synthesis of the Literature

Content from 27 articles was used in the process of developing the evidence-based interventions to increase the use of Guardrails™ safety features by nurses. The literature was organized according to the approaches or interventions recommended. The categories are as follows: smart pump champions and continued quality programs (SPCs & CQPs), education (E), organizational culture and medication errors (OC & ME), and smart pump evaluation and surveillance methods (SPESM). The SPCs and CQPs category included 7 articles while 3 were in the E category, 7 in the OC and ME category, and 10 were in the SPESM category. Table 2.2 presents the evidence table by category.

Smart Pump Champions & Continuous Quality Programs

Patient safety is a priority in hospitals (ISMP, 2013). Orto, Hendrix, Griffith, and Shaikewitz (2015) performed a quality improvement project that measured the impact of a pump champion program aimed to improve compliance with IV smart pump drug libraries over the course of six months. The overall goal of the project was aimed at impacting patient safety by decreasing IV medication errors (Orto et al., 2015). Results revealed that a smart pump champion program was useful, as the drug libraries' compliance rate increased from 83.5% pre-champion implementation to 92% post-champion implementation (Orto et al., 2015). The AAMI (2014) also suggested that facilities adopt and establish a champion when medical devices were implemented in order to improve patient care and ensure proper steps were taken during smart pump integration.

Table 2.2 Evidence Table by Category

Smart Pump Champions/ Continuous Quality	Education	Organizational Culture; Medication Errors	Smart Pump Evaluation & Surveillance Methods
*Orto, Hendrix, Griffith, & Shaikewitz, 2015.	*Gavriloff, 2012.	*Reston, 2013.	*Tan, Nhi, Kong, MacMillian, & McGain, 2013.
*AAMI, 2014.	Kunde, 2015.	Catlin et al., 2015.	*Elias, Moss, Dillavou, Shih, & Azuero, 2013.
*Skledar et al., 2013.	Kirk & Cookson, 2013.	Agyemang & While, 2010.	*Harding, 2012.
Lee, 2015.	*Mariani, Cantrell, Meakim, & Jenkinson, 2015.	Williams, 2015.	Glickman & Orlova, 2015.
*Waterson, 2013.	Crimlisk, Johnstone, & Sanchez, 2009.	*Ohashi, Dalleur, Dykes, & Bates, 2014.	Elias, Moss, Shih, & Dillavou, 2014.
*ISMP, 2009a: Guidelines for smart infusion pumps.	Munn, 2016.	*Murdoch & Cameron, 2008.	ISMP, 2013; Best practice for IV medication infusion.
*Breland, 2010.	*Dennison, 2007.	Harter, 2015.	Vanderveen, 2014.
*Wiest, Longshore, & Harger, 2010.		Vanderveen, 2010.	*Kirkbride & Vermace, 2011.
		Landi, 2016.	*Goulding & Bedard, 2015.
		*Vitoux, Lehr, & Chang, 2015.	*Carlson, Johnson, & Ensign, 2015.
		*IOM, 2011: Standards for developing safe guidelines.	*ISMP, 2009b; IV medication safety.
		Wulff, Cummings, Marck, & Yurtseven, 2011.	*Manrique-Rodriquez et al., 2012.
		*Rothschild et al., 2005.	*Montague, Asan, & Chiou, 2013.
		Nelms, Jones, & Treiber, 2011.	
		*Rosenkoeter, Bowcutt, Khasanshina, Chernecky, & Wall, 2008.	

Note. All highlighted items were articles with high quality evidence ratings. Articles are grouped by columns based on categories: Smart Pump Champions, Education, Organizational Culture, and Surveillance Methods.

In 2010, Skledar, Niccolai, Schilling, Costello, Minni, Ervin, and Urban (2013) initiated a CQI to monitor 6,000 smart pumps in 14 inpatient facilities to increase patient safety. Skledar et al. (2013) offered evidence that a smart pump CQI program was useful for increasing IV medication administration safety. By posting the hospital's CQI findings on the intranet regularly, updating the facilities' smart pump drug libraries on the first of each month and as needed, providing staff education as necessary, and identifying other issues over the course of three years, the facility's compliance score increased to 78% (Skledar et al., 2013).

Implementing smart pumps in hospitals requires assistance from the hospitals' stakeholder's, project managers, and pharmacies (Waterson, 2013). Waterson (2013) suggested that including hospitals' stakeholders, having a continuous nursing education program, and a champion committed to coordinating the smart pumps' information was an effective approach.

Adopting a CQI was important; however, guidelines should be set in place to ensure the safe implementation and use of IV smart pumps (ISMP, 2009a). The ISMP (2009a) suggested an interdisciplinary team (e.g., nursing champions, a pharmacy, an information technology team, biomedical engineers, and infection control) when drug libraries are developed. Breland (2010) also performed a CQI from Spring of 2005 through May of 2006, which included end-user training sessions on April 24th and 25th in 2006. The CQI process was used during the planning, implementation, and post implementation phases of the project with compliance scores ranging from 33% to 39% from November, 2006 through February, 2007 (Breland, 2010). After managing to encourage the hospitals' nursing leaders and managers to get on board to express the importance of using the safety software, updating their drug libraries, and providing their staff nurse’s real-time feedback, their compliance rate increased to 97% (Breland, 2010).

On the other hand, Wiest, Longshore, and Harger (2010) implemented a medication administration team (MAT) that consisted of nurses, pharmacy staff, and information technology team. The team was responsible for implementing smart pumps within five hospitals and ensuring that each hospital had sufficient resources to reach a compliance goal of 85% (Wiest, 2010). Wiest (2010) reported the initial scores were 68-88% among the eight hospitals and ranged from 73-93% during the six-month evaluation period with the use of the MAT team. Also, Wiest (2010) highly suggested that real-time monitoring increased nurses' compliance to using the drug libraries, which improved patient safety and medication administration by preventing harm.

Education

Understanding the "whys" of using Guardrails™ on smart pumps is important, as postulated by Gavriloff (2012). Gavriloff (2012) performed a Deming Cycle that included four stages: plan, do, study, and act. The cycle consisted mostly of communication to nursing staff on the importance of compliance to using drug libraries (Gavriloff, 2012). Gavriloff's (2012) method increased nurses' awareness and adherence to the IV smart pump's medication safety software. In turn, it also increased their compliance score from 85% to 100% compliance.

Mariani, Cantrell, Meakim, and Jenkinson (2015) performed a simulated learning scenario experience for Bachelors of Science in Nursing (BSN)-prepared nursing students to assess nurse's perspective when delivering direct patient care. A pre-and post-survey was completed, and students reported that they were more comfortable with providing direct patient care more safely after the simulated experience (Mariani et al., 2015). Although this study was limited to BSN nursing students, Mariani (2015) suggested further research was needed to validate simulated strategies as useful for teaching safety and quality in nursing. Dennison (2007) educated nurses on the safety of medication administration via computer modules over a six-month period. Dennison's (2007) education program suggested that administrative support is imperative for fostering any change in staff's behavior with medication administration. Dennison (2007) also suggest recruiting an informal champion as a resource for continuous education on medication safety administration.

Organizational Culture & Medication Errors

For any facility to be successful when adopting and implementing software, all stakeholders should be involved with decision making for evaluating, operating, and educating staff on the use of the technology (Reston, 2013). An organization's culture and hospital-specific practices determined how successful they will be (Reston, 2013). Ohashi, Dalleur, Dykes, and Bates (2014) suggested that organizations standardize their compliance methods by upgrading and standardizing their drug libraries, thus decreasing unnecessary pump warnings since smart pumps were useful for reducing IV medication errors, yet look to eliminate end-users' programming errors. Murdoch and Cameron (2008) reviewed numerous studies on IV medication errors and smart pumps. The authors identified that smart pumps have a significant impact on increasing patient safety by preventing programming errors if organizations customize their drug libraries and set hard limits on smart pumps (Murdoch & Cameron, 2008).

Vitoux, Lehr, and Chang (2015) identified ways in which organizations could go about improving the use of their smart pump drug libraries. They strongly suggested that the organization's culture, values, and beliefs about practice impact the integration process of smart pumps, as it requires a team approach and the availability of a diverse variety of stakeholders coming together for the good of collectively integrating technology systems and devices to improve patient safety (Vitoux et al., 2015). The Institute of Medicine (IOM, 2011) suggested that health care professionals should follow all established guidelines and standards set in place at their facilities. Doing so will assist in eliminating poor compliance rates and decreasing the risk of IV medication errors occurring (Rothschild, Keohane, Cook, Orav, Burdick, Thompson, and Bates, 2005). Rothschild et al. (2005) suggested that behavioral factors improved compliance and medication safety. On the other hand, Rosenkoeter, Bowcutt, Khasanshina, Chernecky, and Wall (2008) suggested considering staff nurse's perceptions on the use of smart pumps. In general, organizations should address their culture, their nurse's behavior and attitudes, and take a team approach when smart pumps are integrated into their facilities (Rosenkoeter et al., 2008).

Smart Pump Evaluation & Surveillance Methods

In compliance with the use of smart pump drug libraries, the reason for bypassing its safety feature should be measured, and barriers should be identified and removed (ISMP, 2009b). Evaluating the use of Guardrails™ on smart pumps is an effective way to monitor and identify barriers to its use (Tan, Nhi, Kong, MacMillian, and McGain, 2013). Tan et al. (2013) established a smart pump surveillance method, which included the use of an auditor to monitor nursing end-user use of drug libraries on IV smart pumps. When nursing end-users were found in noncompliance to the use of drug libraries during the auditing period, auditors were required to educate nurses on any concerns regarding the use of drug libraries, which also allowed auditors to identify potential barriers to its use (Tan et al., 2013).

Contrarily, Elias, Moss, Dillavou, Shih, and Azuero (2013) suggested implementing the evaluation of the use of smart pumps via a simulated environment to obtain a much broader understanding of how human factors may impact nurses' use of smart pumps. Conversely, Harding (2012) performed a CQI project that incorporated monitoring quantitative data from smart pumps while utilizing both nursing staff and pharmacy to implement new interventions aimed to increase the use of smart pumps' drug libraries. Doing so, Harding (2012) was able to double nurses' use of smart pumps' drug libraries over a four-month period. Kirkbride and Vermace (2011) identified ways to utilize data reports from their smart pumps to improve clinical practice by standardizing all of their smart pumps and developing what they called a parental infusion device coordinator (PIDC) to perform routine quarterly reports to email to staff, attending staff meetings and annual competencies, and performing compliance rounds to increase nursing staff's use of drug libraries.

Goulding and Bedard (2015) performed a retrospective analysis on drug library compliance reports over a five-month period. They identified that it was imperative that critical care nurses take part in amending and creating their smart pumps' drug libraries and review their CQI reports, to assist with potential education needs, improve their clinical practice, and measure outcomes related to medication errors, patient outcomes, and cost analysis. Carlson, Johnson, and Ensign (2015) developed a safety score used to evaluate 22 hospitals' use of smart pumps to decrease the number of pump alerts. The use of basic infusion mode and the use of hard limits (e.g., end-user's not allowed to proceed with overriding IV medication rate and limits set forth by the institution; ISMP, 2012) and soft limits (e.g., end-user has the choice of overriding IV medication rate and limits set forth by the institution; ISMP, 2012) were three measures used in Carlson et al. (2015) evaluation method. Results revealed that, after adjusting and implementing 117 new pumps within the facilities, and evaluating trends each month, the overall safety scores among the 22 hospitals had improved from 6.41 to 7.57 (Carlson et al., 2015).

Manrique-Rodríguez, Sánchez-Galindo, Fernández-Llamazares, López-Herce, Echarri-Martínez, Escudero-Vilaplana, & Carrillo-Alvarez (2012) were able to identify that, after updating their drug libraries, then initiating and analyzing a Guardrails CQI event reporter program, their compliance was 87% over of the course of the first four months, suggesting that end-user training and readjusting of smart pump limits to correspond to clinical practice were warranted. In a different manner, Montague, Asan, and Chiou (2013) smart pumps' surveillance method utilized nursing end user's perceptions (e.g. end user's trust) on the use of smart pumps as an evaluation tool to assess how smart pumps may influence nurse use and trust in utilizing the technology. Montague's et al. (2013) research resulted in a trust score of (mean 2.97, SD 1.49), indicating that 68% of nurses trusted smart pumps, while 14% did not and 17% were neutral. Overall, the recommendation was that smart pump design (e.g. device speed, reliability, learnability, noise, alarm, navigation, and automation transparency) influences the nurse's trust in the device.

Findings from Hospital-Wide Survey Conducted at the Clinical Site of This Project

Following review of the literature, the AGT looked at data from the hospital-wide survey conducted in January, 2015. All nurses who administered IV medications in the hospital system received a survey (*N*=2,500). The survey contained five questions: What is the primary unit that you work on and which of the following are reasons that are barriers to your using Guardrails™ safety features on the Alaris® smart pumps? One hundred nineteen surveys were returned. Table 2.3, Summary of Hospital-Wide Survey Data identifies the specific barriers.

A variety of authors recommended the use of an implementation team when adding smart pumps and drug libraries to a facility. The facility had already formed the AGT which included all of the necessary professional groups. Analysis of the data from the hospital-wide survey indicated that the majority of nurses (*N*=85) did not use the Guardrails safety features because they could not find the drug or the drug was missing from the drug library. This finding is consistent with the literature. In response to the survey data, the AGT implemented four interventions designed to improve the use of the Guardrails safety features.

Based on this data, Intervention 1 was the development of a drug library that more closely matched those used in the facility and a reorganization of drugs to make them easier to find. The AGT realized that maintenance of the drug library needed to be an ongoing process. Thirty nurses said that using the technology was tedious and did not match the workflow of their unit. Intervention 2 was to acknowledge that the organization's culture influenced adoption of technology. The creation of an Alaris

Guardrails™ Audit Champions (AGACs) influenced the nursing staff to adopt a culture of change within the organization. A few nurses indicated that they did not received proper training. Intervention 3 was to add smart pump training to the new employee orientation program. Intervention 4 was to establish an effective smart pump evaluation/surveillance system while implementing CQI champions.

Table 2.3 Summary of 2015 Survey Data

Reasons	Drug isn't in Library	I can't find the drugs I need	No time/ tedious	No training/ education	Guardrails™ does not match work flow	Other
Number of responses	63	22	8	9	30	19

Note. Nurses could choose all that applied.

Barriers to Implementation

Changing nurse behaviors in relationship to the use of smart pumps with Guardrails™ has the potential to be very challenging. This quality improvement project has the advantage of using evidence-based interventions gleaned from the literature. All of the stakeholders fully engaged should help in behavior change. Ongoing evaluation will help the AGT to monitor progress and identify barriers that may arise during the project.

Summary

After determining that the facility's compliance scores on use of Guardrails™ by nurses were less than the benchmark in February of 2015, the hospital's stakeholders and members of the nursing staff were able to establish the AGT who led the process of promoting use of smart pumps and Guardrails™ safety features by nurses. Chapter III presents the methods used to implement the quality improvement project.

CHAPTER III

METHODS

Chapter III provides information on the methods used to implement the quality improvement project. Doing so, the project's design, sample, setting, interventions, instruments, procedure, and data analysis were all explored in this chapter.

Design

A one sample pre- and post-survey design was used to identify factors that influence the use of Guardrails™ since the implementation of various interventions that started in 2015.

Sample

The project sample consisted of 2,500 nurses who administer IV medications using smart pumps with the Guardrails™ safety feature in the facility. All levels of nurse education were included except for License Practical Nurses (LPNs). Both male and female nurses who work full-time, part-time, and as needed (PRN) participated. All travelers who contracted with the institution were excluded, as only core staff were included in the project. Managers were not included, and nurses were excluded only if they do not employ the IV smart pumps at the facility.

Setting

The quality improvement project occurred in South Carolina at a facility recognized as Magnet®. The institution maintains 58 inpatient and outpatient settings that utilize IV smart pumps with Guardrails™. There are approximately 740 licensed beds in the four hospitals managed by the facility.

Interventions

The AGT was established to develop interventions aimed to increase nurses' awareness, knowledge, and adherence to Guardrails™ safety features on smart pumps. The interventions were based on evidence from the literature, organizational assessment, and data from the hospital-wide survey conducted in 2015.

Intervention 1

The AGT added smart pump training to the new graduate and new hire orientations. The team also created a Guardrails™ website; placed a quick reference guide on the facility's intranet as a resource for staff nurses; and produced Guardrails™ education videos. In addition, education workshops were held for both nurses and managers at various times throughout the year.

Intervention 2

Based on the hospital-wide survey in 2015, the pharmacy re-organized and combined the drug libraries for a more customized universal approach that best suited the organization's culture and clinical practice. Updates to the drug libraries were done quarterly rather than every six-months. Continuing education, library updates, and customization improve compliance (ISMP, 2009a).

Intervention 3

According to Orto et al. (2015), a pump champion program is valuable for improving nursing compliance to drug libraries, and it is vital that the collaboration be done with the hospital's pharmacy leadership, as well as medication safety personnel. The AGT piloted a smart pump audit champion on an adult critical care unit to assess the feasibility of implementing an audit champion throughout the entire facility. The audit champion performed three to five audits on nurses' adherence to Guardrails™, and ensured nurses entered the correct unit identifier (ID) number into the smart pumps for appropriate data retrieval for the pharmacy. The champions were selected for both the day and night shift and were responsible for auditing a total of 15 smart pumps per week.

The champion's role also consisted of educating nurses on the importance of using Guardrails™ and reinforcing the significance of placing the unit's ID number into the smart pumps. Monthly data reports were projected to be given to each unit's manager, who would emphasize the legal liabilities associated with being noncompliant to Guardrails™ on smart pumps. The pilot was a success, and the champions provided useful feedback, suggesting the use of a paperless audit tool, and decreasing the number of audits collected every week. Finally, the Alaris® Guardrails Audit Champions (AGAC) were established and rolled-out throughout various areas within the facility, beginning with critical care. The AGAC process promoted cultural change on the use of Guardrails™.

Intervention 4

Continuous monitoring by the AGAC and Guardrails™ compliance data were performed monthly. Adjustments to the audit process were based on feedback from each area's champion and their managers before reassessing the need to roll-out to the next consecutive area each month. Overall, the current audit process positively impacted nurses' awareness and adherence to Guardrails™ on smart pumps.

Instruments

Outcomes were measured using a hospital-wide survey developed by the facility based on the survey distributed in 2015, informal interviews with several key stakeholders, Guardrails™ data percentage compliance rates retrieved monthly from CareFusion®, but aggregated as yearly statements on self-reported IV medication errors and near miss data reports retrieved from the institution's quality department and extracted into Excel® software.

Hospital-Wide Survey 2017

The Hospital-Wide Survey 2017 was created using the Redcap software. Therefore, "this project was supported by NIH/NCRR Colorado CTSI Grant Number UL1 RR025780. Its contents are the authors' sole responsibility and do not necessarily represent official NIH views" (Harris, Taylor, Thielke, Payne, Gonzalez, Conde, 2009, para 4). Redcap offers a variety of analytical options for interpreting the inquiry results. All information from the survey was collected in Redcap and held under strict security and confidentiality. Both the project's author and a statistician had full access to the survey results in Redcap. The Redcap software allowed survey response to be completely anonymous by selecting the Public Survey Link under the Manage Survey Participant option to ensure responses were kept anonymous, and blinded to the projects' investigators. Participants were invited to take the survey via email, and the information received from each survey response was automatically downloaded into the Redcap software.

The Hospital-Wide Survey 2017 was extracted in whole from the inquiry conducted in 2015. The same survey used in 2015 was also used in 2017 for appropriate comparison. The 2015 survey contained five questions. The first question asks the participant to identify the unit they primarily work on. The second question asks the participants to check all the barriers that apply to the use of Guardrails safety features on smart pumps. There were six barriers: The drug is not in the library, I cannot find the drug I need, There is no time/it is tedious, There is no training/education, and Guardrails™ do not match the work flow. Participants had the option to choose all that apply, and respond with comments to any of the six barriers.

Feedback from the survey was provided to hospital administrators and nursing staff. The responses received from the survey provided insights to make appropriate recommendations for the institution. Thank you notes were sent out to everyone from the original email list after the survey closed.

Interviews with Stakeholders

Throughout the course of the project, several key stakeholders were informally interviewed at various times. Those interviewed included a nursing informatics director, a human factor engineer, and a pharmacist. The nursing informatics director was shadowed for five months during the project. The interview with the informatics director was informal, and all information obtained from the director was used as a reference for contacting other key leaders needed to collect appropriate data to assess how smart pumps and Guardrails™ were used at the facility.

Second, a human factor engineer was interviewed. Again, the interview was informal. Inquiries regarding barriers to nurses' use of Guardrails™ on the smart pump were addressed. Significant information was obtained, and factors such as body mechanics, age, height, device malfunction, and the overall design of the user interface were identified as potential barriers to the use of smart pumps. Finally, the pharmacist interviewed was a member of the AGT and provided pertinent information about the history of smart pumps at the institution and information on data collection on Guardrails™ usage.

Percentage of Guardrails™ Usage

The proportion of Guardrails™ usage by nurses was captured every month from a measuring tool used by CareFusion®, the makers of the Alaris® pumps. CareFusion® sends data to the institution based on their Guardrails™ usage as compared to other facilities that use smart pumps from CareFusion®. The tool supplies the facility with a monthly count of infusions using the Guardrails™ Suite MX and those not using the Guardrails™ Suite MX. The information is captured, and a percentage of usage score is calculated. The reports were sent to the pharmacy department every month, and pharmacy would run the reports via the hospital's web server. Later, the pharmacy would send the information to the AGT.

Self-reported IV Medication Errors

The quality department collected information on medication errors and near misses as they were all self-reported by staff at the facility through the hospital's patient safety net (PSI) reporting portal. The data retrieved from the reporting tool was converted using Excel® software for review as needed. Reports from the application provide data monthly. For this project, however, compliance reports were obtained monthly, but aggregated as yearly accounts.

Procedure

The procedure for this quality improvement project is described below. First, the institutional review board was notified about the quality improvement project to obtain valid institutional approval. Second, interventions 1-4 were implemented over a 2-year period. Third, one week before the survey was distributed, managers were instructed by the hospital’s Assistant Chief Nursing Officer (ACNO) to reinforce to staff nurses the importance of taking the survey to gain a high response rate to take part in the survey.

Since Sunday was the start of the work week at the facility, the survey was sent out on the following Friday, September 15, 2017. The survey was made available for voluntary participation for 2 ½ weeks to ensure all staff nurses would have allocated enough time to complete the survey. The participants were encouraged by their unit's manager to complete the survey before the 2 ½ weeks deadline. All participants were sent a friendly reminder on the Sunday after the survey opened that states, "work with the survey will be ending soon, please complete the survey and send, thank you." The rationale for taking the survey was provided to each participant and presented at the beginning of each survey invitation. Instructions presented in the survey offered information, suggesting that the nine-question survey will take less than five minutes to complete, and feedback from the survey will assist in making the medication administration safer at the facility. In effort to thank all the participants that were invited to take part in the survey, a "thank you" note was broadcasted via email to all participants from the original email list after the survey closed. Completed surveys were automatically downloaded to the Redcap software where the results were analyzed.

Interviews

Several stakeholders were informally interviewed at various times throughout the quality improvement project. First, a pharmacist was interviewed and used as a reference at different intervals throughout the project. The pharmacist was asked to provide data on Guardrails™ utilization, information on medication administration times/schedules, and information on the historical evidence pertaining to the initiation of smart pumps at the facility. The pharmacist also volunteered information about their wireless system and how data from the smart pumps is captured from each unit monthly. The pharmacist indicated that the institution lacks an effective strategy to capture the data from specific units. Therefore, it was difficult to track compliance information from each unit. Thus, the creation of a AGACs served as a resource for nurses on the unit. The AGACs assessed 10-15 smart pumps per week to verifying that both Guardrails™ and the correct unit number are programed into the smart pumps. The AGAC then placed the information collected during their visual inspection into the facilities audit tool available online via Verge software. The AGAC also served as a direct resource for educating nurses on the importance of adherence to Guardrails™ and placing the unit's number into the smart pumps. Overall, communication with pharmacy had been ongoing via email as questions about the project evolved.

The nurse informatics director was then interviewed. The informatics leader was shadowed for a course of five months during the project. The informatics director served as a resource for allocating information needed from various stakeholders in the facility. The informatics director offered a broader insight into the cost analysis associated with smart pumps and how cost played a major role in setting priorities in the institution. The informatics leader insisted that due to the facilities' current priorities, the decision to purchase the pump-integrated system with the smart pump connected to electronic health record (EHR) was not a feasible solution for the institution at this time. Integration of the smart pumps into the EHR offered the facility a solid solution to the automatic extraction of unit-specific smart pump data for tracking and auditing instead of having nurses manually program their unit-specific ID number into the smart pumps. This would enable the pharmacy to create unit-specific compliance reports.

Lastly, a human factor engineer was also informally interviewed. The engineer offered new insightful information on the use of smart pumps. The engineer identified potential human factors that are barriers to the use of Guardrails™. Factors include the age and height of the nurse that potentially contribute to the efficient use of the smart pumps. Other factors include malfunction of the smart pump devices and the design of the user interfaces on the smart pumps. The three members interviewed were beneficial with providing information needed to complete this project.

Data Analysis

The data allocated for this project included results from both the 2015 and 2017 surveys and Guardrails™ compliance data rates compared to self-reported IV medication errors from 2015 to 2017. A one-sample *t*-test was used to analyze and compare both the 2015 and 2017 survey results. The outcome was measured from 2015 to 2017, and Guardrails™ usage rates and self-reported IV medication errors were compared using a two-sample portion *z*-test. The information collected and analyzed in this quality improvement project offered a systematic organizational assessment to identify factors that influence the use of Guardrails™ by nurses, so that recommendations for future change could be made in order to foster continued progress toward the benchmark set by the facility of 90-100% of the time.

CHAPTER IV

RESULTS

Chapter IV presents the results from the practice improvement project. The EBP question that guided this project was, "For hospital based nurses using smart pumps with Guardrails™, what are factors that influence the use of smart pumps with Guardrails™ after implementing interventions based on the 2015 systematic organizational assessment and hospital-wide survey as measured by 2017 hospital-wide systematic organizational assessment and survey, percent of use of Guardrails™ by nurses, and self-reported IV medication errors per month. Both the 2015 and 2017 surveys were created and administered using Redcap software. After the survey closed, all data were downloaded to Excel® and analyzed using SAS statistical software (version 9.4).

Descriptive statistics were used to analyze and interpret data collected from the project. Barriers to use of Guardrails™ with smart pumps from the 2015 survey were compared to barriers reported in the 2017 survey following the interventions.

Self-reported IV Medication Errors

Data on self-reported IV medication error were collected from the institutions quality department and downloaded for analysis into Excel® software. SAS analysis was used to compare nurses' use of Guardrails™ before (2010-2014) and after

(2015-2017) the interventions. A *z*-test was used to analyze the data. The *p*-value was significant at.00001. The proportion of nurses using Guardrails™ on smart pumps was significantly higher (.81) after the interventions than before (.71). Table 4.1 presents these data.

In 2008, IV smart pumps were integrated at the facility to decrease the risk of IV medication errors. In 2010, there were approximately 978 reported cases of IV medication errors at the facility (Figure 4.1). In addition, Figure 4.1 shows data on the count of self-reported IV medication errors recorded from 2010-2017. Guardrails™ were then added to the smart pumps in April of 2010, with a compliance goal set at 90-100%. However, the facility identified that nurses' used Guardrails™ less than 75% of the time (Figure 4.2).

Use of Guardrails™

Data on Guardrails™ utilization rates were collected from pharmacy and exported to Excel® and yearly utilization rates were calculated. A yearly account of Guardrails™ utilization scores is displayed in Figure 4.2. Guardrails™ utilization scores continued to decline in 2011 and 2012. Scores averaged 69% (Figure 4.2). In 2013, scores averaged 74% and 75% in 2014. The practice improvement project began in 2015. As of September 2017, the average utilization rate of Guardrails™ was 88% for the year, and 90% for the month.

Guardrails™ utilization and self-reported IV medication errors were reported from 2010-2017 were captured using Excel® analytical tools. The information was generated based on yearly averages of both Guardrails™ utilization and accounts of self-reported IV medication errors by year. The report revealed that in 2011, self-reported IV medication errors had reached its peak of 1529 reported cases compared to low Guardrails™ utilization score of 69% (Figure 4.3).

Table 4.1 Guardrails™ Score Pre and Post

Observations	Total number Infusions	Total number of Guardrails™	Proportion of Guardrails™
2010-2014	12812959	9140165	.71335
2015-2017	4935361	3988099	.80807
Proportion Test Results			
	variances	***Z* test statistics**	**P-value**
	5.4042E-8	-407.423	.00001

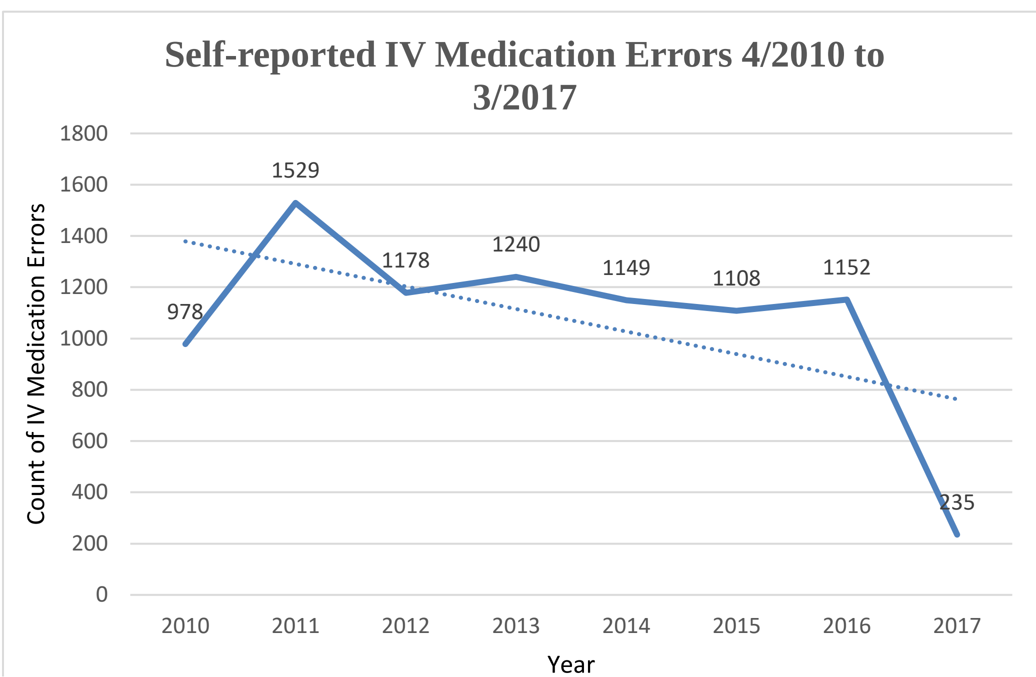

Figure 4.1. All Self-reported IV Medication Errors 4/2010 to 3/2017

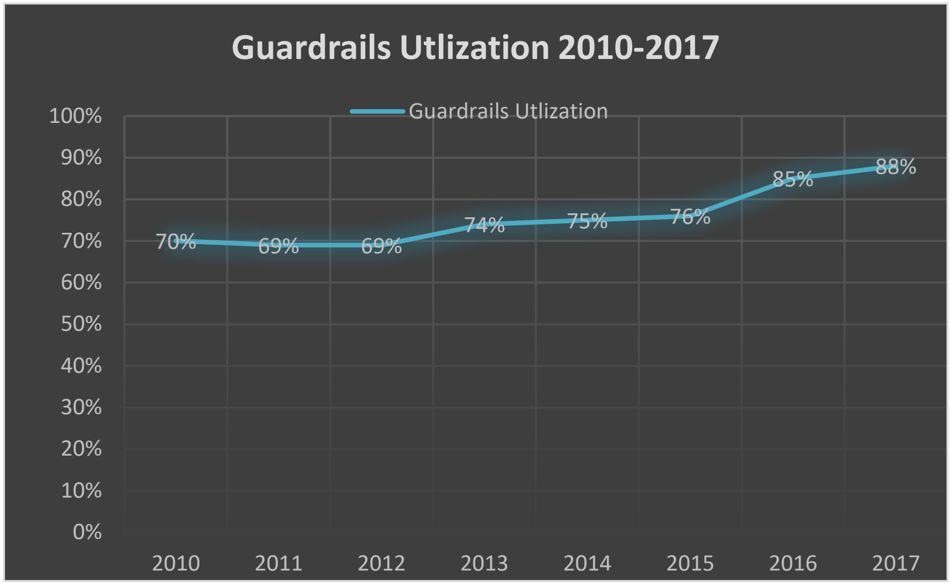

Figure 4.2 Yearly Account of Guardrails™ Utilization Scores

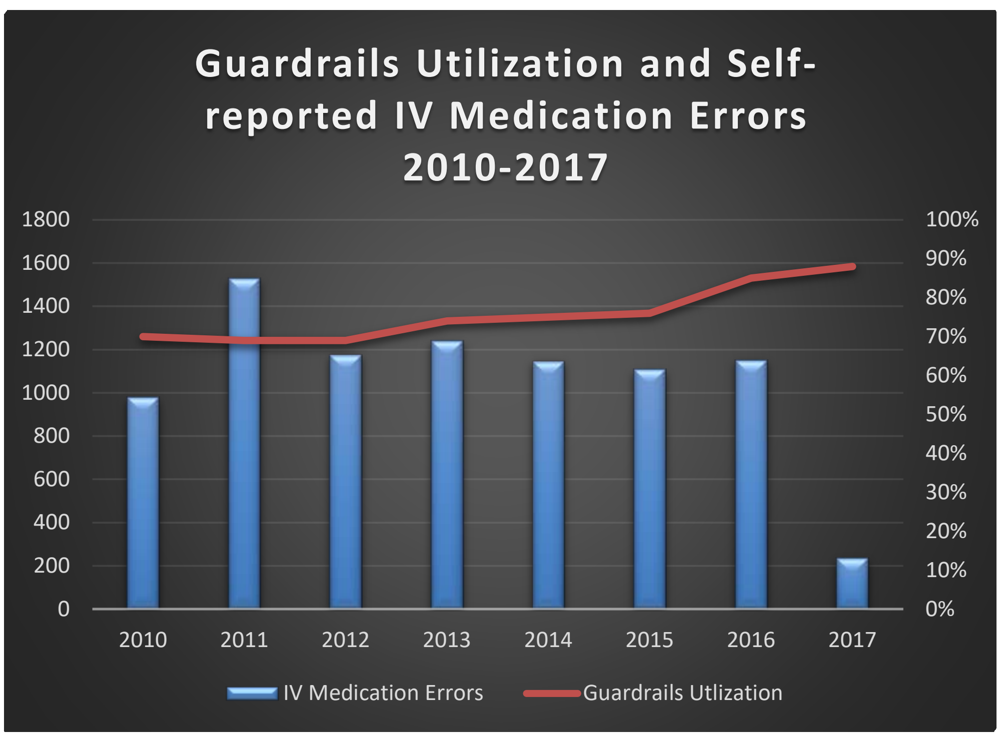

Figure 4.3 Guardrails™ Utilization and IV Medication Errors 2010-2017

In contrast, by 2015 there were 1108 reported cases of self-reported IV medication errors, and Guardrails™ utilization scores averaged 76% (Figure 4.3). Guardrails™ utilization increased by 10% in 2017 and self-reported IV medication errors decreased. There were 235 reported cases of self-reported IV medication errors as of March 2017 (Figure 4.3). A retrospective view of Guardrails™ utilization over-time is displayed in Figure 4.4. Figure 4.4 also illustrates Guardrails™ utilization before and after the AGT initiated the practice improvement process in March of 2015. Utilization scores averaged 74%-75% in 2014 before the AGT was established in 2015, while current compliance scores as of September 2017 averaged 88%.

2015 Pre-Survey Data

The pre-survey was conducted in January of 2015 (*N*=119). The data collected from this survey provided insights on barriers to nurse's use of Guardrails™ on smart pumps. Figure 4.5 illustrates the proportion of participants who completed the survey based on specific nursing areas. Question 2 on the survey asked, "What unit do you primarily work on?" Data collected from the responses to question 2 were categorized using themes based on all nursing areas identified in the survey. Codes were established in Table 4.2. The codes created in Table 4.2 were used to interpret various data throughout this project. Each category were identified based on responses from the survey. Themes were created as they related to the specific areas in each category. Each code, MS, C, M, I, S, and P, represents its corresponding nursing area listed from each theme (e.g., MS= All Medical/Surgical Floors, C= Critical Care, M= Meduflex Float Pool, I= Infusion Cancer Center, S= Specialty Areas, P=Pediatrics).

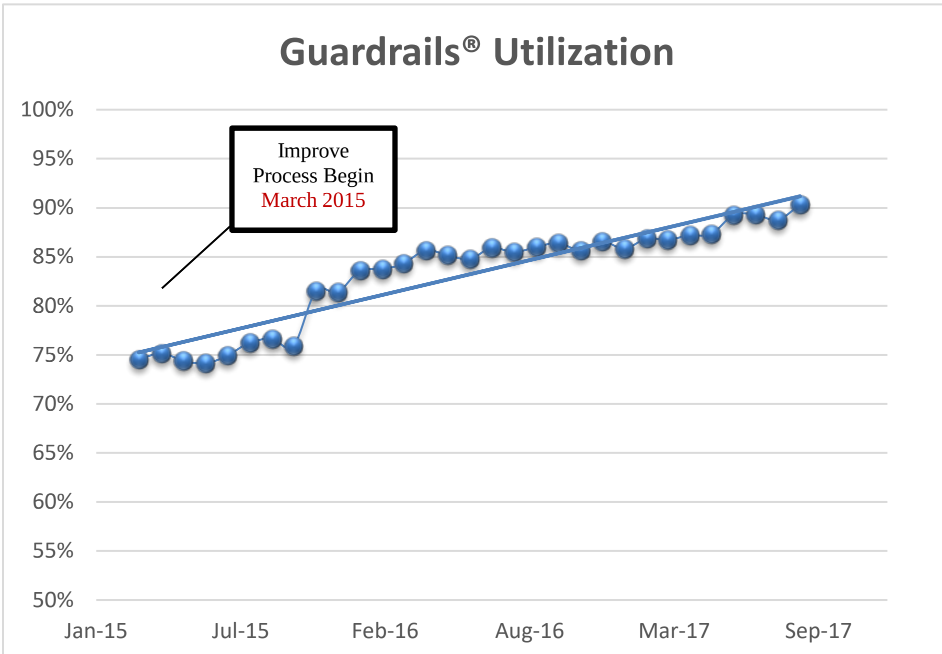

Figure 4.4 Guardrails™ Utilization Over Time

Table 4.2. Key for Nursing Areas

Survey Key for Nursing Areas		
Category	**Theme**	**Code**
Cardiovascular, GI, Renal/Transplant, Oncology, Neurology, Ortho, Stepdown units, Transitional Care units,	All Medical/Surgical Floors	MS
ED, PACU, all Adult ICU's	Critical Care	C
Critical Care both Pediatrics and Adults, Med/Surg. Floors	Meduflex	M
Infusion Cancer Center	Infusion Center	I
Transplant Infusion, Senior Care Unit, Heart and Vascular Prep/Recovery, Cath Lab, Interventional Radiology, Adult Cardiovascular Clinic	Specialty Areas	S
Pediatric ICU's, Special Care Nursery, Mother Baby, Med/Surg. units	Pediatrics	P

**Note*. GI= Gastroenterology, ED =Emergency Department, PACU =Post Anesthesia Care Unit, ICU = Intensive Care Units.

The percentage of nurses who completed the survey from various nursing units is presented in Figure 4.5. The information in Figure 4.5 reveals that of 119 participants, 50% (*n*=60) were from various Medical/Surgical nursing areas both impatient and outpatient. Twenty percent (*n*=24) were from Critical Care, 8% (*n*=10) were from the Infusion Cancer Center, and 12% (n=14) were from various Specialty care areas, and 7% (*n*=8) were from Pediatrics. Results from the pre-survey are presented in Table 4.3 as a frequency table. Question 3 of the pre-survey identified barriers to nurses' use of Guardrails™ by providing each participant six check all that apply options.

There were (*N*=119) responses, 52.94% (*n*=63) of participants agreed that drugs are not available in the library, 18.49% (*n*=22) agreed that they have trouble finding the drugs in the drug libraries, 6.72% (*n*=8) agreed that they don't have enough time/using Guardrails™ is tedious, 7.56% (*n*=9) agreed that they never received training or education on using Guardrails™, 25.21% (*n*=30) agreed that existing Guardrails™ setting did not match their workflows in their work areas, and 15.97% (*n*=19) agreed there were other issues which prevented them from utilizing the Guardrails™ features.

Survey questions 4, 5, and 6 extended from question 3 of the survey and provided the option for participants to write-in comments. Question 4 in the pre-survey asked, "If you selected, I am having trouble finding the drugs I need in the different Guardrails™ libraries, please tell us which drug(s) you are having trouble finding and which libraries you use." Information presented in Figure 4.6 is based on written responses to question 4 by nursing areas.

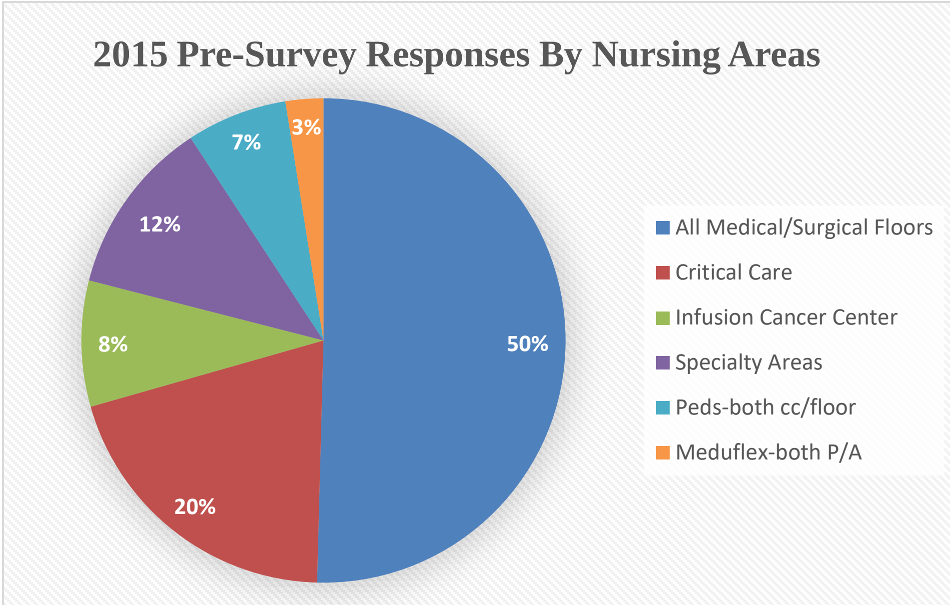

Figure 4.5 2015 Pre-Survey Participants

Table 4.3 2015 Pre-Intervention Barriers

2015 Pre-Survey Question 3: Barriers												
Variables*	I have looked/asked and the drug I need isn’t in the Guardrails library		I am having trouble finding the drugs I need in the different Guardrails libraries		I don’t have enough time to use Guardrails/using Guardrails is tedious		I didn't receive training or education on using Guardrails		Existing Guardrails settings don't match with workflows in my area		Other	
	N	%	N	%	N	%	N	%	N	%	N	%
No	56	47.06	97	81.51	111	93.28	110	92.44	89	74.79	100	84.03
Yes	63	52.94	22	18.49	8	6.72	9	7.56	30	25.21	19	15.97

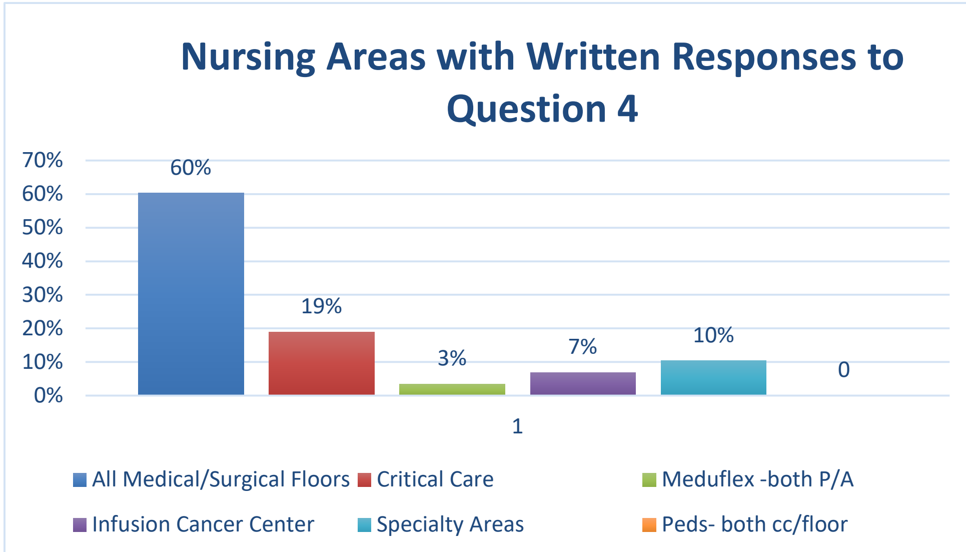

Figure 4.6 Percent of Written Responses to Pre-Survey Question 4

Only 58 participants provided comments on survey question 4. Sixty percent (*n*=35) were from Medical/Surgical Floor areas, 19% (*n*=11) were from Critical Care areas, 3% (*n*=2) were from Meduflex areas, 7% (*n*=4) were from Infusion Cancer Center areas, and 10% (*n*=6) were from all inpatient and outpatient Specialty areas. There were (*n*=0) written responses to question 4 from Pediatrics areas. The information captured in Table 4.4 was extracted in whole based on participants written responses to question 4. Each nursing unit responses were categorized by areas and codes were established for each unit. The legend for Table 4.4 is illustrated in Table 4.2.

Question 5 from the survey asked, “If you selected I have looked/asked and the drug I need isn’t in the Guardrails™ library, and please tell us which drug is/are missing.” Information pertaining to question 5 evoked several key responses. The data presented in Figure 4.7, reveals all survey participants who responded in written form to question 5 (*n*=15). There were 73% (*n*=11) responses from participants in Medical/Surgical Floor areas, 13% (*n*=2) from Critical Care areas, and 13 % (*n*=2) from all Specialty areas. There were no responses from Pediatric, Infusion Cancer Center, or Meduflex nursing areas. All written responses to question 5 were extracted in whole and displayed in Table 4.5 based on nursing areas. Table 4.2 provides a legend to identify each nursing unit code.

Question 6 asked, “If you selected other, please tell us what any other barriers to using Guardrails™ are?” Of the 19 responses, 47% (*n*= 9) written comments were from participants on the Medical/Surgical Floors areas, 21% (*n*=4) from Critical Care areas, 5% (*n*=1) from Infusion Cancer Center areas, 16% (*n*=3) from Specialty areas,

Table 4.4 Written Responses to Pre-Survey Question 4

Nursing Unit Category	Written Response to Survey Question: 4
C	Azithromycin Banana bag w/ thiamine Keppra Keppra, citate for CRRT Lots of ab1, some chemo drugs Magnesium. Also, mag given for resp distress should be 2g in 15 minutes; for mag replacement, should be 1-2 hours Some ab1 we use Trane1amic acid Vimpat
I	Ab1, drugs that need to be titrated, and chemo regiments like cytarabine and cyto1an Can't remember Dose appropriate - cyto1an, cytarabine - I have to program outside of the soft stop for most non-RCHOP/BMT uses They have since been updated
M	Alteplase Don't remember
MS	Ab1 - will try to remember which one and write down Ab1 but can't remember the name Alteplace for IR lytics (dose usually 1 mg/hr - drug, 5 mg/250mL bag, 50 mL/hr). Also, alteplase for use with EKOS system. Drug concentration 10 mg in 250 mL run at 25 mL/hr. This is per manufacturer of EKOS machine due to the low flow and high pressure needed to push the TPA to the clost. EKOS coolant of normal saline also needs to run at 35 mL/hr. Can't remember Certain chemo regimens De1amethasone, ondansetron, bolus fluids DHE DHE and some ab1 Don't remember IV levetiracetam, 0.45% sodium chloride Keppra Keppra, Vimpat Kytril Lasi1 Levaquin Multiple ab1 Octreotide Ondansetron (zofran), ceftria1one (Rocephin); I would recommend adding common combo chemos, like etoposide/adriamycin/vincristine if possible Phenergan Sodium bicarb TPN Uncommon ab1 Zithroma1 Zofran Zofran/odansteron, furosemide/lasi1 (correct dosage or ability to change is not in there)
S	Adenosine gtt for FFR Alteplase Alteplase for EKOS Can't remember e1actly right now, but common ab1 Sodium phosphate Thiamine

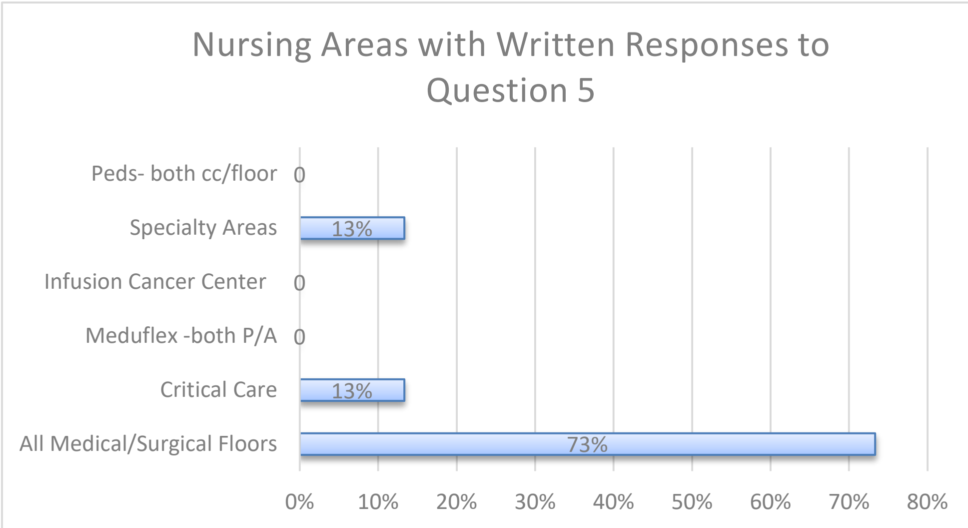

Figure 4.7 Percent of Written Responses to Pre-Survey Question 5

Table 4.5 Written Responses to Pre-Survey Question 5

Nursing Unit Category	Written Response to Survey Question: 5
C	I don't see any trouble with the library, I just don't like the pumps period. They are awful and need to be replaced with better overall pumps. Same
MS	IVIG 1 Amiodarine bolus Azactam is not in peds critical care <20 kg Due to previous e1perience IV levetiracetam, 0.45% sodium chloride Keppra Ondanestron, combo ondensetron/de1amethesone, combo etoposide/do1orubicin/vincristine Phenergan TPN TPN & lipids are confusing to find
S	Alteplase Can't remember

and 11% (*n*=2) from Pediatric areas, which includes both intensive care and medical/surgical Pediatric nursing areas (Figure 4.8). The information displayed in Table 4.6 was extracted in whole and includes all written comments from question 6. Table 4.2 provides a legend to identify each nursing unit code.

2017 Post-Survey

Data collected from the post-survey used both Excel® and SAS (version 9.4) to analyze the query. There were 155 responses to the 2017 post-survey. Unlike the pre-survey, the post-survey included three questions on demographics one question to assess the facilitys' current 2017 AGAC process. Like the pre-survey, question 2 of the post survey asked, "What unit do you primarily work on?" The data results were then analyzed using SAS frequency tables. Again, all data collected from questions which contained a written response were categorized using themes based on nursing areas, and codes were created from each unit theme (Table 4.2). There were 153 total responses to question 2.

The data reported in the Figure 4.9 reveals that of 153 responses, 45% (*n*=69) of survey respondents were from all Medical/Surgical areas, 23% (*n*=36) were from Critical Care areas, 7% (*n*=10) were from Infusion Cancer Center areas, 1% (*n*=2) were from all other Specialty nursing areas, which included both inpatient and outpatient, 7% (*n*=10) were from all Pediatric nursing areas, and 17% (*n*=26) were from the Meduflex areas. A representation of all newly added demographics to the post-survey are presented in Table 4.7.

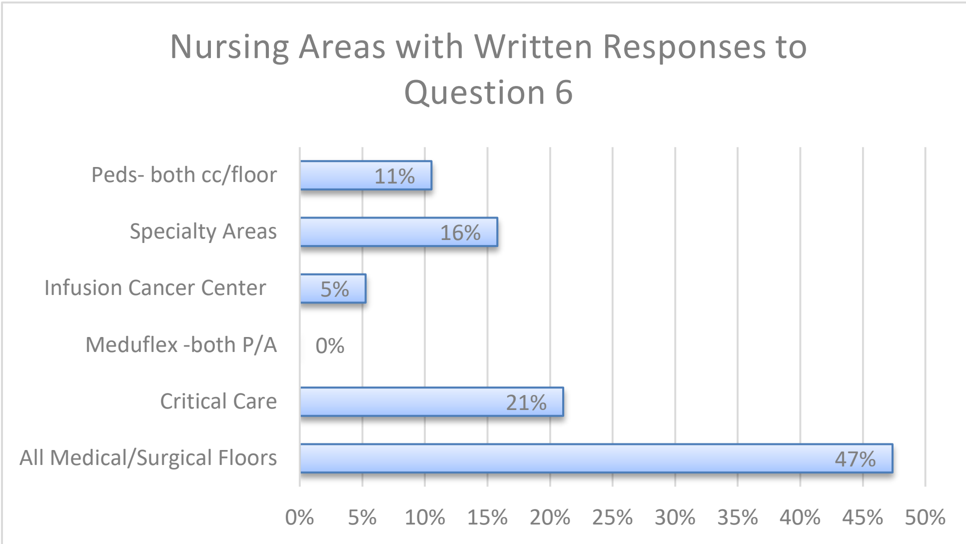

Figure 4.8 Percent of Written Responses to Pre-Survey Question 6

Table 4.6 Written Responses to Pre-Survey Question 6

Nursing Unit Category	Comments: Survey Question: 6
C	Don't reply to me It can be tedious for basic fluid admin. And it takes all thinking out of med admin, which is detrimental to nursing skill development. When a patient is crashing, I have to change over the IV pump settings to Critical Care versus Med Surg patient. When trying to set up vasopressors this delay with having to reset the pump is an issue. When patients have multiple bags of potassium ordered, for the sake of continuity and keeping infusions running, I would like to be able to program a primary potassium infusion and piggy back a second bag of potassium as a secondary infusion. Alaris will not let you set primary potassium and secondary potassium, you have ot set a primary basic infusion and a secondary potassium infusion to run 2 bags continuously over 2 hours without interruption.
I	Most of the drugs I've requested be added to the oncology library have been added already
MS	After you select medication, you have to manually plug in dose, volume, and rate - I've seen other hospitals have common drugs plugged in with dose, volume, and rate At times the ordered dose is outside Guardrails Have had issues with IV abx not used often on the unit I am unsure if our pumps received the wireless update sent over the past few weeks I have issues with secondary infusions and being able to set Guardrails. Also, maybe some education on making sure we are choosing the right fluids. Lastly, TPN, the dextrose is translated to % of dextrose on bag and in MAR, but on pumps it's in grams/mL. I don't know how to convert that and most often the number I think it would be isn't available on the selected list. IVPBs that have more than one drug, dex, zofran etc. not on list No barriers No problems None
P	No barriers
S	Have been using basic infusion due to IV being for hydration only No issues None that I can recall

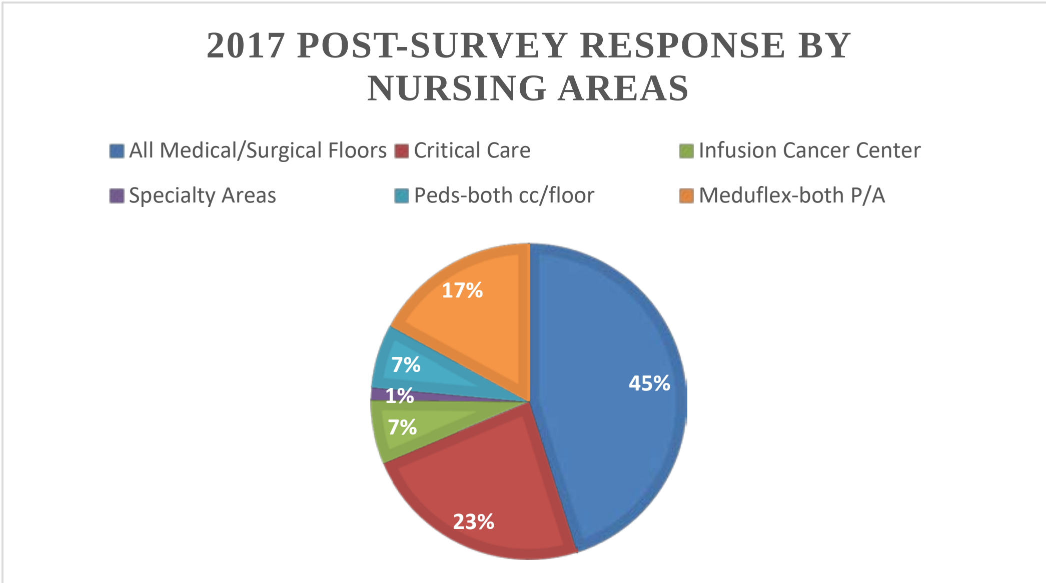

Figure 4.9 2017 Post-Survey Response by Nursing Areas

Table 4.7 Demographic Variables

Variables	**Post-Survey (*N*=155)** *N*	**%***
Age		
18-28	42	27
29-39	66	43
40-50	30	19
51-61	15	10
61+	2	1
Level of Education		
Associates	30	20
Bachelors	110	72
Graduate	13	8
Years of Nursing Experience		
0-5	86	56
6-11	35	23
12-17	16	10
18+	17	11

**Note*. All percentages in this table were reported from SAS analysis (version 9.4) and rounded to its nearest whole number.

Question 3 in the 2017 post-survey asked, "What is your current level of education?" Figure 4.10 displays the distribution of education from the 153 respondents. Twenty percent (*n*=30) held an Associates in Nursing, 72% (*n*=110) held a Bachelors in Nursing, and 8% (*n*=13) held a Graduate degree in Nursing. A description of the second demographic variable from question 4 of the post-survey is presented in Figure 4.11. Question 4 asked, "Years of nursing experience?" Data revealed that there were 154 responses, with 56% (*n*=86) having 0-5yrs. of nursing experience, 23% (*n*=35) with 6-11yrs. of nursing experience, 10% (*n*=16) with 12-17yrs. of nursing experience, and 11% (*n*=17) with 18+ yrs. of nursing experience. Age was the last demographic variable assessed in the post-survey.

Figure 4.12 represents information extracted from responses to question 5 of the post-survey assessment. There were 155 responses, and data revealed that 27% (*n*=42) were 18-28yrs. of age, 43% (*n*=66) were 29-39yrs. of age, 19% (*n*=30) were 40-50yrs. of age, 10% (*n*=15) were 51-61yrs. of age, and 1% (*n*=2) were 61+yrs. of age. The frequency table presented in Table 4.8 reports information obtained from question 6 in the 2017 post-survey. Question 6 from the post-survey asked nurses to identify barriers to use of Guardrails™ by providing each participant six check all that apply options. Of the 155 responses, 35.48% (*n*=55) of participants agreed that drugs are not available in the library, 10.32% (*n*=16) agreed that they have trouble finding the drugs in the drug libraries, 12.26% (*n*=19) agreed that they don't have enough time/using Guardrails™ is tedious, 3.87% (*n*=6) agreed that they never received training or education on using Guardrails™, 11.61% (*n*=18) agreed that existing Guardrails™ settings did not match their workflows, and 26.45% (*n*=41) agreed that there are other barriers to their use of Guardrails™.

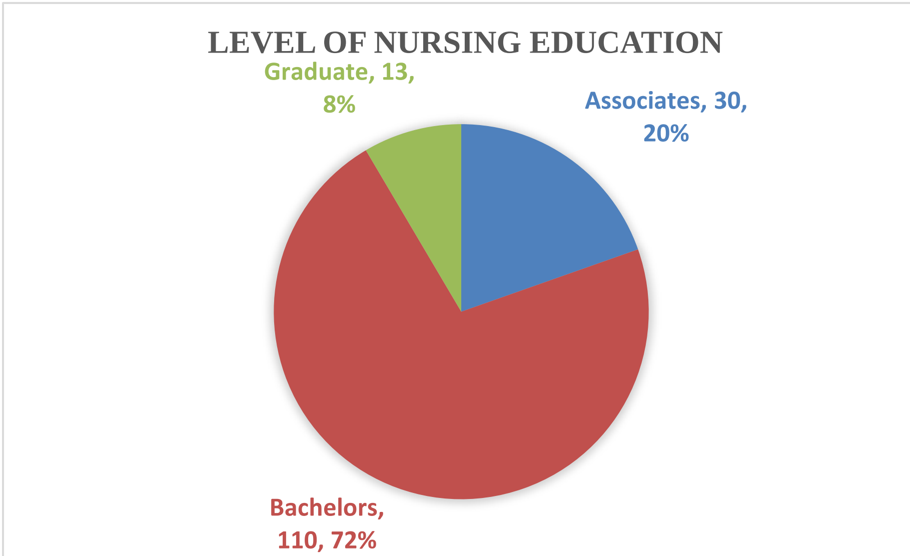

Figure 4.10 Level of Nursing Education

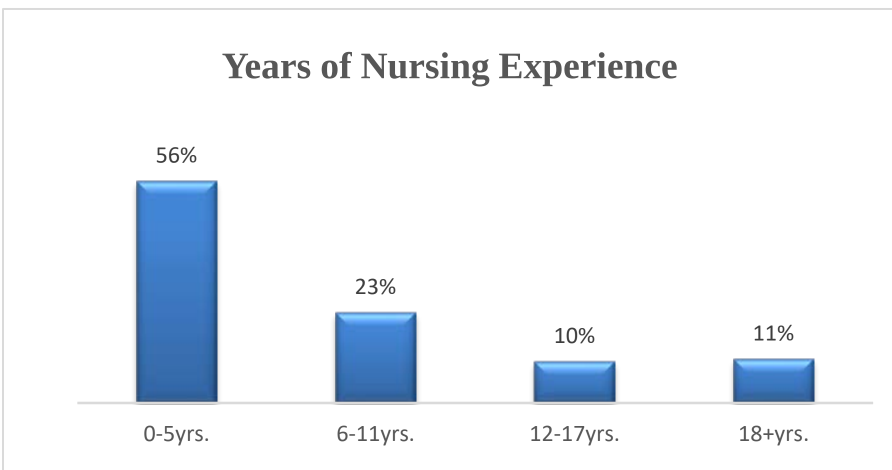

Figure 4.11 Years of Nursing Experience

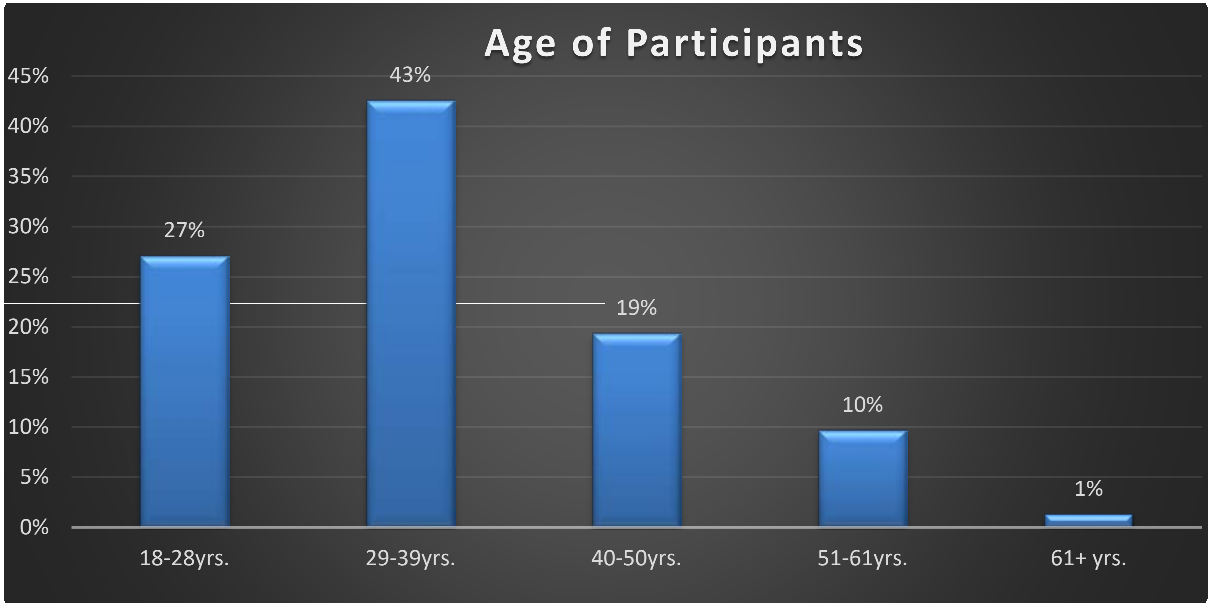

Figure 4.12 Age of Participants

Table 4.8 2017 Post-Intervention Survey

2017 Post-Survey Question 6: Barriers												
Variables*	I have looked/asked and the drug I need isn't in the Guardrails library		I am having trouble finding the drugs I need in the different Guardrails libraries		I don't have enough time to use Guardrails/using Guardrails is tedious		I didn't receive training or education on using Guardrails		Existing Guardrails settings don't match with workflows in my area		Other	
	N	%	N	%	N	%	N	%	N	%	N	%
No	100	64.52	139	89.68	136	87.74	149	96.13	137	88.39	114	73.55
Yes	55	35.48	16	10.32	19	12.26	6	3.87	18	11.61	41	26.45

There were 40 responses to question 7 presented in Figure 4.13. Question 7 asked, “If you selected I am having trouble finding the drugs I need in the different Guardrails™ libraries; please tell us which drug(s) you are having trouble finding and which libraries you use.” Results revealed that 48% (*n*=19) of nurses from all Medical/Surgical areas, 25% (*n*=10) from Critical Care areas, 20% (*n*= 8) from Meduflex areas, 5% (*n*=2) from the Infusion Cancer Center areas, 0% (*n*=0) from Specialty areas, and 3% (*n*=1) from Pediatric areas provided written responses to question 7 (Figure 4.13). All written responses to survey question 7 were extracted in whole and presented in Table 4.9. The codes for each nursing unit category presented in table 4.9 is displayed in Table 4.2.

Question 8 from the post-survey also required participants written responses. There were 27 written responses to survey question 8. Results illustrated in Figure 4.14 provides a description on all written responses by nursing unit areas. There were 44% (*n*=12) written responses from Medical/Surgical areas, 26% (*n*=7) from Critical Care areas, 26% (*n*=7) from Meduflex area, 4% (*n*=1) from the Infusion Cancer Center, and 0 responses from both Pediatrics and Specialty areas. All written responses to survey question 8 were extracted in whole and presented in Table 4.10. The codes for each nursing unit category presented in table 4.10 is displayed in Table 4.2.

Responses by nursing areas are displayed in Figure 4.15. Question 9 asked, “If you selected other, please tell us what any barriers are to using Guardrails™.” There were 43 written responses. The information from Figure 4.15 reveals that 42% (*n*=18) of all written responses to question 9 were from all Medical/Surgical areas, 33% (*n*=14) from Critical Care areas, 16% (*n*=7) from Meduflex areas, 7% (*n*=3) from the Infusion Cancer

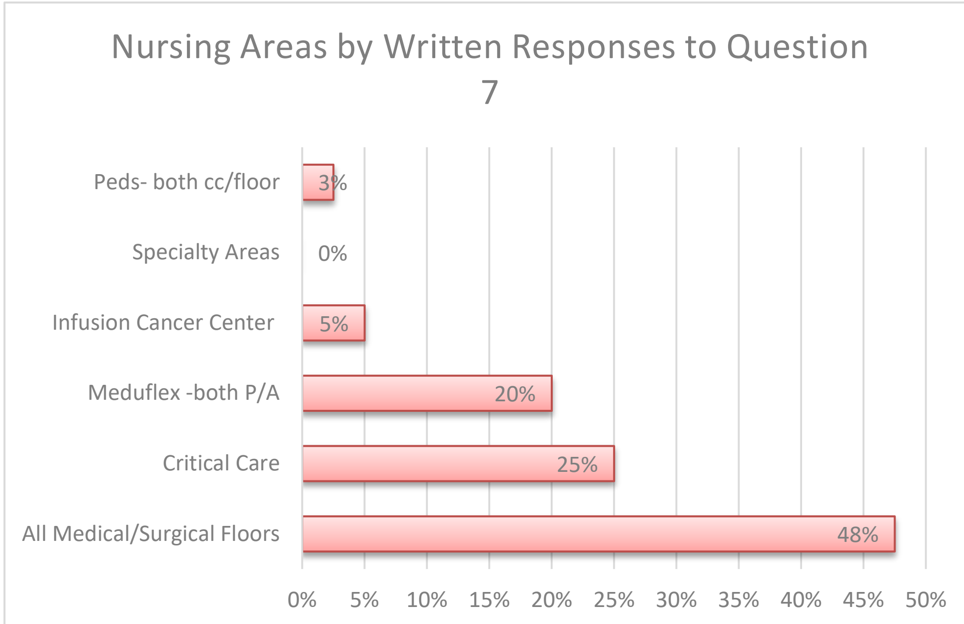

Figure 4.13 Percent of Written Responses to Post-Survey Question 7

Table 4.9 Written Responses to Post-Survey Question 7

Nursing Unit Category	Written Responses to Survey Question: 7
C	DEFIBROTIDE I can't remember In pacu we frequently use ansethsia settings for drips, they are frequently not avalible in nursing libraries kcentra Mainly IVF such as plasmalyte and things like that n/a NA Several antibiotics - I always report this to my pharmacist Standard and mixed IVF choices are minimal and/or confusing to select. When it takes 60+ seconds to program/find a simple IVF, I am MUCH less likely to use the guardrail settings for this infusion.
I	clinical trial drugs; new drugs just on market, olaratumumab, a couple of others but cannot recall specifically at this time. oncology avolumab is on study
M	adult Cannot remember I don't recall. I always use the guardrails. But if I don't it's because I can't find the drug. It has been a long time since that has happened n/a Not sure several; can't remember which ones this is the only reason i would not use the guardrails, i always use them because of a mistake i made about 8 years ago.
MS	Adult Med/Surg library; albumin Albumin for liver patients, rate not defined antibiotics; chemotherapies Blood Products chemo drugs not present in Adult guardrail library Desmopressin, adult drugs I am able to find most of the drugs I need I cant recall now but it has happened a couple of times. Search by name I can't remember exactly.... I think it was a sodium/dextrose combo. I dont recall I dont remember I have trouble deciding which category to look under for the drug/fluid I am about to hang I use the Oncology library. If we have to administer chemo on other floors (ICU, cardiology) they need their own cardiology setting IV guardrail drugs, Keppra IVF's n/a past in time problem, cannot remember the name of the drug There have been maybe one or two, I can't remember now. It has been a long time. Use Oncology library. Our medications that have multiple drugs in them are not listed; such as Ondansetron and Dexamethasone or Etoposide, Doxorubicin & Vincristine.
P	cant remember

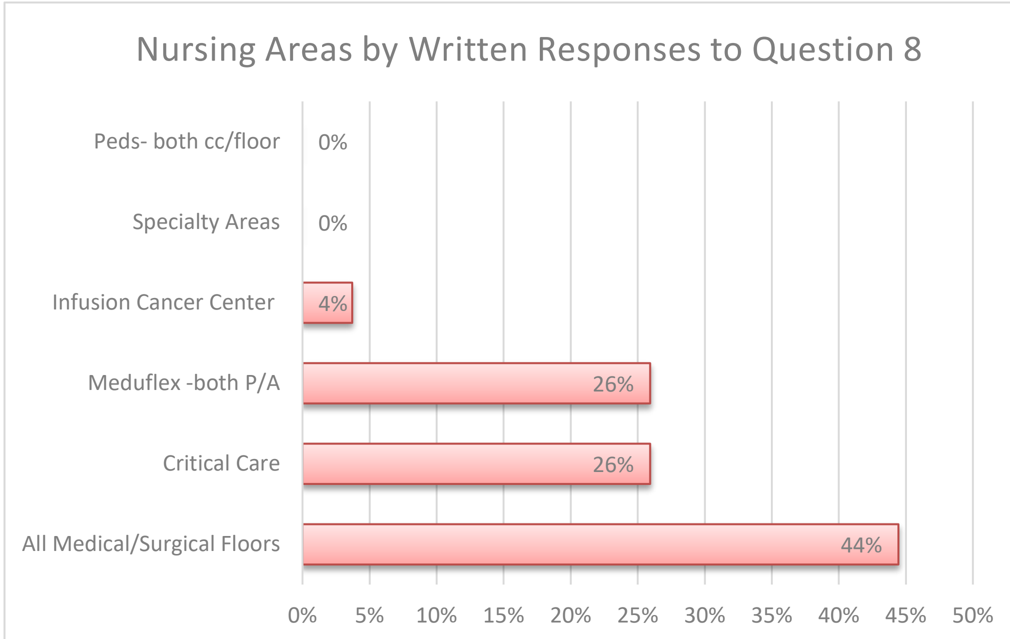

Figure 4.14 Percent of Written Responses to Post-Survey Question 8

Table 4.10 Written Responses to Post-Survey Question 8

Nursing Unit Category	Comments: Survey Question: 8
C	certain anti-rejection meds n/a NA neosynepherine Potassium 20mg/100mL Several antibiotics - I always report this to my pharmacist
I	avolumab
M	don't remember at this time For everything I hang I look in the guardrails, if I dont see it I look a second time then hang the med as basic. I can't think of any off the top of my head. I do not remember. rarely have this issue. n/a numerous cant remember
MS	albumin As listed above. can't remember the actual drug name Can't remember; it's been awhile since this has happened. chemo drugs not present in Adult guardrail library D5 1/2NS + additive Desmopressin I am able to find most of the drugs I need idk mix drugs (zofran and decadron) for example Phenergan occasionaly on certain brains Same as above

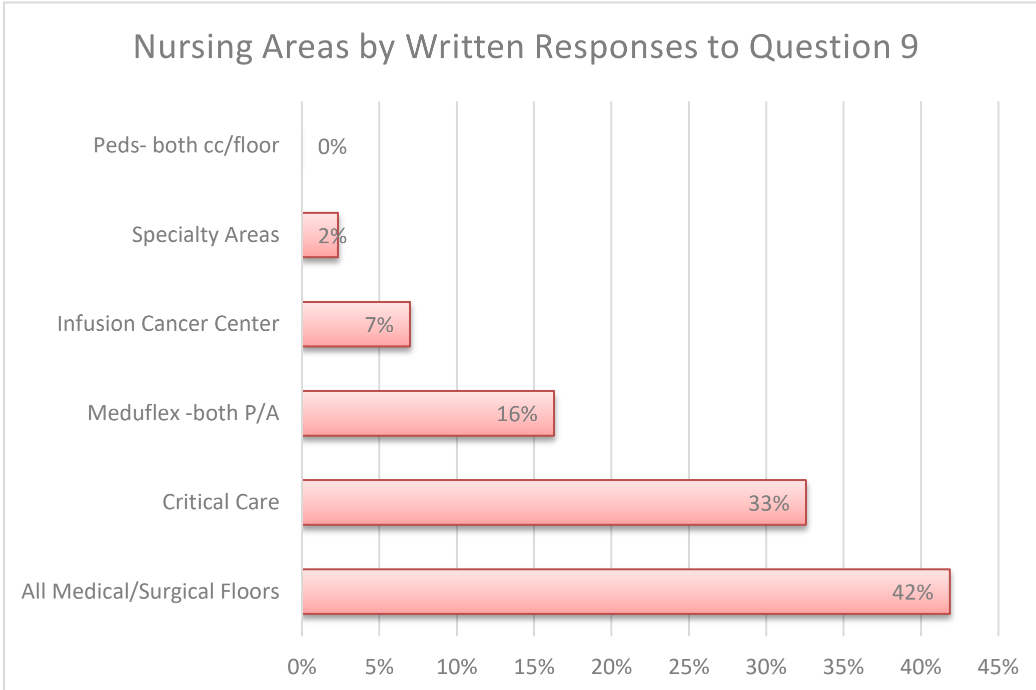

Figure 4.15 Percent of Written Responses to Post-Survey Question 9

Center areas, 2% (*n*=1) from Specialty nursing areas, and 0 responses from Pediatric areas. All written responses to survey question 9 were extracted in whole and presented in Table 4.11. The codes for each nursing unit category presented in table 4.11 are displayed in Table 4.2.

The final question from the 2017 post-intervention query reports data related to the facility's current 2017 AGAC process, and accounts on staff nurses participation with the smart pump champions on their nursing units. Question 10 in the post-survey asked, "Have you had the opportunity to work with the Alaris Guardrails™ Audit Champions on your unit or any other nursing units?" There were 148 responses, with 76% (*n*=113) reporting they had not work with the Alaris Guardrails™ Audit Champions, and 24% (*n*=35) reporting that they had worked with the Alaris Guardrails™ Audit Champions (Figure 4.16).

Analysis of Pre and Post-Survey

Several frequencies and *t*-tests were performed in SAS (version 9.4) to assess for differences among the pre and post-survey, and differences amongst each demographic variable (e.g. level of education, years of nursing experience, and age) compared to barrier choices listed in question 3 of the pre-survey and question 6 of the post-survey (e.g., barrier 1: I have looked/asked and the drug I need isn't in the Guardrails™ library, barrier 2: I am having trouble finding the drugs I need in the different Guardrails™ libraries, barrier 3: I don't have enough time to use Guardrails™/using Guardrails™ is tedious, barrier 4: I didn't receive training or education on using Guardrails™, barrier 5: Existing Guardrails™ settings don't match with workflows in my area, barrier 6: other).

Table 4.11 Written Reponses to Post-Survey Question 9

Nursing Unit Category	Comments Survey Question: 9
C	correct concentration of drugs not in pump Habit I am unaware this is protocol or at least don't recall receiving education about it being required. Does it have to be for meds other than IVF or for everything on a pump? Is it required? ALSO, it is the responsibility of the RN to update the patient's weight daily so they receive the right amount of drugs - I FREQUENTLY see this not being done. This is especially important for BP, cardiac, and sedation meds and should be addressed ASAP. I have not experienced any barriers I have only found one drug not in library. I always us i use it most of the time. I use the guardrails with drips, but for MIVF, find it more of a hassle to search for fluid rather than just use basic infusion Most of the time I find the drugs I need N/A No barriers No barriers. Only running antibiotic and it's not available as primary option some drugs don't have same concentrations or calculations used in unit h I use guardrails if the drug isn't listed, I send a message to have it updated I don't have trouble using the guardrails, I use them consistently as long as the medication I need is listed I have no barriers, guardrails are used
I	I use guardrails if the drug isn't listed, I send a message to have it updated I don't have trouble using the guardrails, I use them consistently as long as the medication I need is listed I have no barriers, guardrails are used
M	air in line I always use the library I don't have any barriers to Guardrails, I don't use IV pumps often or in pressure situations I don't have barriers to guardrails currently, all drugs I have mentioned have been added I have not met any barriers yet. N/A No barriers
MS	all of the drugs we give are in the Alaris pump I always use guardrails, occassionally may change rate depending on access but have not had any issues I do not have any issue or barriers with the guardrails I do not work with the Alaris pumps often, and do not find many barriers to their use. I don't have any barriers. I always use guardrails. I don't really have trouble using it. I have been able to use the Guardrails library without difficulty i have no barriers I have no issues using the guardrail library I have no issues with Guardrails I typically use the guardrails features I've had very rarely used 'basic infusion' on med/surg units. N/A None of the above, I have received proper training and use the guardrails appropriately. none, I use them all the time patient specific needs ie-chf & vanco @ 250 ml/hr 750ml bag Tedious s I have yet to use a pump as a new grad

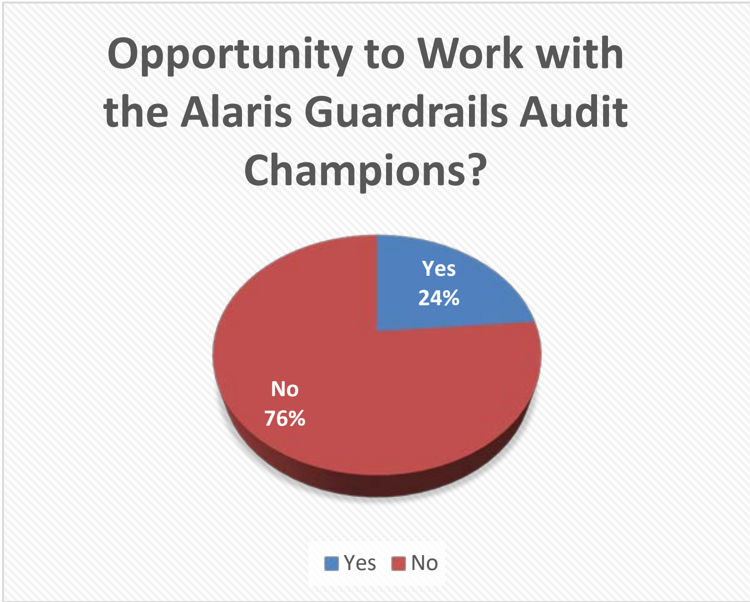

Figure 4.16 Work with Alaris Guardrails™ Audit Champions

The frequencies of variables compared in the pre and post survey is presented in Table 4.12. The information in Table 4.12 shows the frequency distribution of barriers by pre and post-intervention. The *p*-value for the chi square test was .0038 for barrier one, .0526 for barrier two, .1276 for barrier three, .1830 for barrier four, .0033 for barrier five, and .0375 for barrier six as presented in Table 4.12. The results showed about 35.48% (*n*=55) of post intervention looked/asked and the drug was not in Guardrails™ library as compare to pre intervention about 52.94% (*n*=63) (*p* value=.0038), 11.61% (*n*=18) of post-intervention existing Guardrails™ settings don't match with workflows as compared to pre-intervention about 25.21% (*n*=30) (*p* value=.0033), and 26.45% (*n*=41) of post-intervention identified that there were other barriers to the use of Guardrails™ as compared to pre-intervention about 15.97% (*n*=19) (*p*-value =.0375). All other barriers reported a *p*-value >.05 showed no significances.

Table 4.12 Frequency Distribution of Barriers by Pre and Post-Interventions

Variables*	**Pre-Survey (*N*=119)** *N*	*%*	**Post Survey (*N*= 155)** *N*	*%*	***p*-value**
1. I have looked/asked and the drug I need isn't in the Guardrails library.					
No	56	47.06	100	64.52	.0038
Yes	63	52.94	55	35.48	
2. Iam having trouble finding the drugs I need in the different Guardrails libraries.					
No	97	81.51	139	89.68	.0526
Yes	22	18.49	16	10.32	
3. I don't have enough time to use Guardrails/using Guardrails is tedious.					
No	111	93.28	136	87.74	.1276
Yes	8	6.72	19	12.26	
4. I didn't receive training or education on using Guardrails.					
No	110	92.44	149	96.13	.1830
Yes	9	7.56	6	3.87	
5. Guardrails settings don't match with workflows in my area.					
No	89	74.79	137	88.39	.0033
Yes	30	25.21	18	11.61	
6. Other					
No	100	84.03	114	73.55	.0375
Yes	19	15.97	41	26.45	

The frequency distribution of barriers by level of nursing education is displayed in Table 4.13. The *p*-value for the chi square test was .8282 for barrier one, .3244 for barrier two, .1759 for barrier three, .4008 for barrier four, .6025 for barrier five, and .1744 for barrier six as displayed in Table 4.13. The chi square test for all *p*-value results were >.05, which indicated there were no significant differences among the level of nursing education on barriers.

The frequency distribution of barriers by years of nursing experience is displayed in Table 4.14. The *p*-value for the chi square test was .0876, for barrier one, .1611 for barrier two, .1097 for barrier three, .5157 for barrier four, .1875 for barrier five, and .1744 for barrier six as presented in Table 4.14. The results revealed no significant differences exist between years of nursing experience and barriers to Guardrails™ usage.

The frequency distribution of barriers by age is displayed in Table 4.15. The *p*-value for the chi square test was .0581 for barrier one, .0432 for barrier two, .3989 for barrier three, .9592 for barrier four, .0847 for barrier five, and .2242 for barrier six as displayed in table 4.15. The results showed a *p*-value < .05 for barrier two (*p*-value=.0432), suggesting there is enough evidence to support that differences exist between the age of nurses and trouble with finding the drugs in different Guardrails™ libraries. The post-intervention barriers by age showed about 18.18% (*n*=12) of participants 29-39yrs, and 9.52% (*n*=4) of the participants 18-28yrs, post-intervention had trouble finding the drugs in the different Guardrails libraries (*p*-value=.0432). All other *p*-values provided no significance since all other values were >.05.

Table 4.13 Frequency Distribution of Barriers by Level of Nursing Education

Post-Survey (*N*=153)	Associates		Bachelors		Graduate		*p*-value
Variables*	***N***	**%**	***N***	**%**	***N***	**%**	
1. I have looked/asked and the drug I need isn't in the Guardrails library.							.8282
No	18	60	71	64.55	9	69.23	
Yes	12	40	39	35.45	4	30.77	
2. Iam having trouble finding the drugs I need in the different Guardrails libraries.							.3244
No	28	93.33	97	88.18	13	100	
Yes	2	20.29	13	11.82	0	0	
3. I don't have enough time to use Guardrails/using Guardrails is tedious.							.1759
No	29	96.67	93	84.55	12	92.31	
Yes	1	3.33	17	15.45	1	7.69	
4. I didn't receive training or education on using Guardrails.							.4008
No	30	100	105	95.45	12	92.31	
Yes	0	0	5	4.55	1	7.69	
5. Guardrails settings don't match with workflows in my area.							.6025
No	28	93.33	96	87.27	11	84.62	
Yes	2	6.67	14	12.73	2	15.38	
6. Other							.5782
No	23	76.67	81	73.64	8	61.54	
Yes	7	23.33	29	26.36	5	38.46	

Table 4.14 Frequency Distribution of Barriers by Years of Nursing Experience

Post-Survey (N=154)	**0-5yrs.**		**6-11yrs.**		**12-17yrs.**		**18+yrs**		***p*-value**
Variables*	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	
1. I have looked/asked and the drug I need isn't in the Guardrails library.									
No	49	56.98	27	77.14	13	81.25	11	64.71	.0876
Yes	37	43.02	8	22.86	3	18.75	6	35.29	
2. Iam having trouble finding the drugs I need in the different Guardrails libraries.									
No	73	84.88	33	94.29	15	93.75	17	100	.1611
Yes	13	15.12	2	5.71	1	6.25	0	0	
3. I don't have enough time to use Guardrails/using Guardrails is tedious.									
No	77	89.53	33	94.29	12	75	13	76.47	.1097
Yes	9	10.47	2	5.71	4	25	4	23.53	
4. I didn't receive training or education on using Guardrails.									
No	81	94.19	34	97.14	16	100	17	100	.5157
Yes	5	5.81	1	2.86	0	0	0	0	
5. Guardrails settings don't match with workflows in my area.									
No	72	83.72	32	91.43	15	93.75	17	100	.1875
Yes	14	16.28	3	8.57	1	6.25	0	0	
6. Other									
No	68	79.07	23	65.71	9	56.25	13	76.47	.1744
Yes	18	20.93	12	34.29	7	43.75	4	23.53	

Table 4.15 Frequency Distribution of Barriers by Age

Post-Survey (N=155) Variables*	18-28yrs.		29-39yrs.		40-50yrs.		51-61yrs.		61+yrs.		p-value
Barriers	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	
1. I have looked/asked, and the drug I need isn't in the Guardrails library.											
No	23	54.76	48	72.73	15	50	12	80	2	100	.0581
Yes	19	45.24	18	27.27	15	50	3	20	0	0	
2. I am having trouble finding the drugs I need in the different Guardrails libraries.											
No	38	90.48	54	81.82	30	100	15	100	2	100	.0432
Yes	4	9.52	12	18.18	0	0	0	0	0	0	
3. I don't have enough time to use Guardrails/using Guardrails is tedious.											
No	37	88.10	58	87.88	28	93.33	11	73.33	2	100	.3989
Yes	5	11.90	8	12.12	2	6.67	4	26.67	0	0	
4. I didn't receive training or education on using Guardrails.											
No	40	95.24	64	96.97	29	96.67	14	93.33	2	100	.9592
Yes	2	4.76	2	3.03	1	3.33	1	6.67	0	0	
5. Guardrails settings don't match with workflows in my area.											
No	33	78.57	58	87.88	29	96.67	15	100	2	100	.0847
Yes	9	21.43	8	12.12	1	3.33	0	0	0	0	
6. Other											
No	32	76.19	47	71.21	25	83.33	8	53.33	2	100	.2242
Yes	10	23.81	19	28.79	5	16.67	7	46.67	0	0	

Summary

The information presented in Chapter IV was analyzed to identify factors that influenced the use of Guardrails™ by nurses. The findings indicated that all but one demographic variable (e.g. age) were related to identified barriers. All nurses regardless of education, time in the workforce, and age identified similar barriers to use of Guardrails™ on smart pumps. There was a correlation between IV medication errors and use of Guardrails™. The higher the percentage of use of Guardrails™ the lower IV medication errors. Although the facility did not meet the benchmark, data indicated that the interventions did increase the use of Guardrails™ from 63% to 88%. It will be vital for the AGT to establish a plan for continuous quality improvement with the goal of meeting the benchmark set at 90 to 100% of the time.

CHAPTER V

DISCUSSION

The purpose of this quality improvement project was to conduct a systematic organizational assessment to identify the factors that influence the use of Guardrails™ by nurses, implement interventions based on the assessment, measure outcomes, and make recommendations for future change in order to foster continued progress toward the facility's goal set at 90-100% Guardrails™ use. The project used a descriptive approach to conduct an organizational assessment. The project included all nursing units with staff nurses who utilized Guardrails™ on IV smart pumps in their daily workflows. All statistical information collected for this project was analyzed using SAS statistical software (version 9.4) and Excel® software. The SAS (version 9.4) analysis software was used to analyze frequencies, using the *t*-test to compare results from the 2015 pre-survey and the 2017 post-survey. Frequencies, the *t*-test, and *z*-scores were also used to analyze and compare Guardrails™ compliance data and self-reported IV medication errors. Excel® was used to categorize data from the "primary working unit" variable to identify themes and formulate codes for each area of nursing; doing so allowed a visual presentation of the frequency of responses from each nursing area. Tables and graphs were also created in Excel® to display the results.

Implications of Findings

The data results from the Guardrails™ compliance report and self-reported IV medication errors between 2015 and 2017 provided enough evidence to suggest that a structured continuous education plan is essential to increase nurses' awareness and adherence to policies and procedures governing the use of Guardrails™ on IV smart pumps. The data collected in this project was assessed and the information obtained offered reasonable answers to each of the four prospective questions mentioned in Chapter I.

Question One

The question of whether a relationship existed between Guardrails™ compliance and self-reported IV medication errors were probed by asking, "As IV smart pump's Guardrails™ compliance rate increases, does the rate of IV medication errors decrease?" Data revealed that as the IV smart pumps Guardrails™ compliance rate increases, the rate of IV medication errors decreases, having *z*-test results with a *p*-value less than .00001. The *p*-value was significant and suggested that the proportion of nurses using Guardrails™ was high post interventions (.81), compared to pre-intervention (.71), which also implies that as Guardrails™ compliance increased, self-reported IV medication errors decreased. The literature has emphasized that a structured continuous education program is beneficial when smart pumps are first implemented in hospitals. The evidence strongly suggests that in order to foster increased compliance scores, collaboration with hospital stakeholders, pharmacy, nurses, unit managers, and information technology, forming unit champions, and establishing a continuing education program are all essential elements that directly impact Guardrails™ compliance and improved patient safety outcomes.

Question Two

The second question postulated in Chapter I asked, “Does the number of IV medication errors decrease with the implementation of each intervention? If so, what factors significantly impact increasing compliance rates and why?” The institution incorporated several change processes to increase their nurses’ awareness, adherence, and compliance to Guardrails™ on smart pumps. The facility updated their drug libraries each quarter to allow sufficient time for new drugs to be added to their smart pumps, added education on the use of Guardrails™ for new hires and new nurses’ orientation, consolidated their drug libraries for a universal approach to Guardrails™ use and features, offered educational workshops, quick reference guides, re-organized their drug libraries, and implemented an audit champion initiative in order to assist with increasing staff nurses’ knowledge, awareness, and adherence to the safety feature on smart pumps. Beginning in 2015, interventions implemented throughout the course of this project and positively contributed to an increase in Guardrails™ compliance, which decreased the rate/risk of IV medication errors. The data reported that a correlation exists between Guardrails™ usage and IV medication errors.

Recognizing the correlation between Guardrails™ usage and self-reported IV medication errors answers the question of whether the number of IV medication errors decreases as Guardrails™ compliance increases, but how it was impacted by implementation of each intervention cannot be determined. However, the factor of “awareness” contributed to a decrease in IV medication errors, since all interventions directly impacted nurses’ awareness to utilize Guardrails™ on smart pumps. Hence, increasing Guardrails™ usage is regarded as an effective preventive measure to decrease IV medication errors. As a result, monitoring monthly Guardrails™ compliance data as yearly reports, compared to the yearly accounts of self-reported IV medication errors, offered the institution a means to assess their progress towards the 90-100% benchmark, assess their current policies and procedures on the use of Guardrails™ on smart pumps, and offered them guidance with decision making on any future interventions that needed to be made moving forward.

Question Three

The third inquiry from Chapter I addressed data on new barriers to the use of Guardrails™ that were reported from the post-survey. The question asked, “Are there any new barriers identified by staff nurses, and if so, what are these barriers?” The 2017 post-survey offered an array of data to assess and determine if new barriers on the use of Guardrails™ existed post-implementation of all the various interventions from 2015-2017. For example, 26.45% (*n*=41) of the nurses assessed post-intervention identified that there were other barriers to the use of Guardrails™, as compared to 15.97% (*n*=19) of them pre-intervention (*p*-value =.0375), which suggested other barriers were identified. All data captured as written comments in the post-survey suggested that there were new barriers. For example, three participants, all from the Critical Care areas, reported each statement presented below.

"I am unaware this is a protocol or at least don't recall receiving education about it being required. Does it have to be for meds other than IVF or for everything on a pump? Is it required?"

"I have only found one drug not in library. I always use it most of the time."

"I use the guardrails with drips, but for MIVF, find it more of a hassle to search for fluid rather than just use basic infusion."

All the comments presented above suggest that the new barriers include unclear policies and procedures governing the use of Guardrails™, drugs being missing from the libraries, and interference with workflows. The information revealed that it is worthwhile to update policies governing IV medication administration, for the pharmacy to quickly update new medications as they become readily available for use on smart pumps, and reinforce saying "no to basic infusion" while emphasizing the importance of correctly using the IV technology for the effective and compliant use of Guardrails™ in all nursing areas. In addition, all significant *p*-values in the post-surveys' chi-square test was .0038, which suggests that about 35.48% (*n*=55) of the nurses, post-intervention, looked/asked and the drug was not in the Guardrails™ library, compared to 52.94% (*n*=63) of nurses pre-intervention (*p*-value=.0038). Approximately 11.61% (*n*=18) of the post-intervention agreed that Guardrails™ settings did not match with their workflows, as compared to 25.21% (*n*=30) pre-intervention (*p*-value=.0033), and 26.45% (*n*=41) of the nurses assessed post-intervention identified that there were other barriers to the use of Guardrails™, as compared to 15.97% (*n*=19) of them pre-intervention (*p*-value =.0375).

Question Four

The last question from Chapter I asked, “Does the post-nursing survey report an increase in staff nurses’ knowledge and awareness regarding the proper utilization and adherence to the IV smart pump’s Guardrails™ policies and procedures?” The data reported in this project suggest that incongruences may exist with nurses’ awareness of the proper utilization and current procedures on the use of Guardrails™ (see reports from Question Three). Also, the results presented in Figure 4.16 report that regarding awareness of the current procedure surrounding implementing an Alaris Guardrails™ Audit Champion on all nursing units hospital-wide, 76% (*n*=113) of the 148 respondents reported that they had not had the opportunity to work with the audit champions and 24% (*n*=35) reported that they had worked with the audit champions. The information gathered suggest that nurses are aware of this new procedure governing the use of Guardrails™.

Limitations

There were several limitations identified in the project. First, the application of using a survey tool presented biases, such as the risk of participants providing untruthful answers, the risk of data error occurrences with some respondents who did not respond, and the risk of participants misinterpreting the “yes” and “no” questions. Second, similar demographic data should have been used in both surveys to offer broader insights on variations that may have existed among the variable “age” and all barriers pre- and post-interventions since the frequency distribution of post-intervention barriers by age showed about 18.18% (*n*=12) of participants 29-39yrs, and 9.52% (*n*=4) of the participants 18-

28yrs, post-intervention had trouble finding the drugs in the different Guardrails libraries (*p*-value=.0432). Third, it could not be determined if the same participants who participated in the pre-survey also participated in the post-survey; having the same participants in both surveys could have increased the reliability of the results. Also, there was a low response rate for both the pre-survey (*N*=119) and post-survey (*N*=155). Even so, the post-intervention survey had a higher response rate, which was partially due to having the hospital's ACNO present the post-survey to unit managers and their nursing staff as compared to the pre-survey, which was presented by members of the AGT.

As a result, incorporating a more creative plan to engage staff to participate in surveys is warranted since higher response rates offer fewer non-response biases. However, using the same survey for both the pre- and post-interventions was beneficial for identifying any new barriers to the use of Guardrails™, identifying a need to make any new changes to current interventions intended to increase nurse use of Guardrails™ on smart pumps, and offering significant information on the overall progress of the current interventions.

Implications for Nursing

Guardrails™ were added to the smart pumps in 2010 to assist with lowering the risk of IV medication errors. There were several self-reported cases of IV medication errors within the facility even after Guardrails™ were added. The institution failed to establish an effective education and compliance monitoring plan when the smart pumps were integrated, and nurses failed to use the safety features on smart pumps. Both nursing leaders and nursing staff need to understand the purpose of the safety features on smart pumps as well as the policies and procedures governing their use. Nurses need to be aware that compliance with Guardrails™ supports adhering to the five rights of IV medication administration; in this case, the “right dose/rate” will be established when Guardrails™ are in use.

When continuous educational initiatives are implemented in facilities, continual support from hospital leaders is essential, because staff tend to participate more readily when stakeholders are included in initiatives. Patient safety is always the first priority, so nurses need to understand the true value of using Guardrails™ on smart pumps despite fostering a culture of workarounds. Nursing leaders need to emphasize that it is imperative that staff nurses understand how to correctly operate the IV smart pump technology and utilize its safety features because it decreases the risk of IV medication errors and improves patient safety and outcomes when used properly. In order to ensure that Guardrails™ compliance data are captured from each nursing unit when nursing staff are required to enter a specified unit ID number into the smart pumps for appropriate data retrieval, nursing leaders need to establish an effective method to share each unit’s ID number with all nursing staff, specifically Meduflex float pool nurses, in the event that they would need to float to other units. Ongoing education on the use of Guardrails™ on smart pumps is necessary for hospital facilities.

More importantly, all information summarized in this quality improvement project provides nursing stakeholders with the opportunity to address their reported compliance rates by emphasizing legal liabilities if there’s an issue of noncompliance with the use of Guardrails™ on smart pumps (ISMP, 2009).

Recommendations

Smart pumps are smart when nursing end-users are properly trained on utilizing the technology to administer IV medications. Also, nursing end-users need to make the right decision to use the appropriate library within the smart pump's safety features. Failure to comply with the safety features increases the risk of IV medication errors, which runs the risk of harming or even killing a patient. However, when policies are not accurately set in place to govern certain procedures within facilities, and failing to establish an effective education and compliance monitoring plan upon integrating smart pumps, the staff will lack support and education regarding making the right decisions. As a result, questions arise regarding the procedure and patients are put at risk.

Therefore, nursing leaders need to collaborate with hospital stakeholders and their quality departments to re-assess policies governing IV medication administration. IV medication administration policies need to reflect evidence-based data on the use of smart pumps with Guardrails™. Nursing leaders need to also ensure that Guardrails™ drug libraries are continuously updated as formulary changes are made, and establish an effective plan of sharing each units' ID number with all staff nurses, especially Meduflex (float pool nurses) in the event that they would need to float to other units.

Establishing an effective on-going education plan and monitoring monthly Guardrails™ compliance data compared to self-reported IV medication error occurrences are important matters to consider when smart pumps are used in hospitals. A systematic organizational assessment was conducted to identify barriers to nurses' use of Guardrails™ on smart pumps. The project demonstrated that when barriers to the use of

Guardrails™ are identified, addressing those issues are just as important as nurses complying with the safety features of smart pumps. When issues pertaining to drug libraries are presented by nursing end-users and if they are not addressed, the issue of noncompliance to Guardrails™ will continue, self-reported IV medication errors will increase, and the risk of harming a patient will also increase. This project demonstrated that implementing various structured education processes and informational initiatives that aim to increase nurse’s knowledge, awareness, and adherence to Guardrails™ on smart pumps has a positive impact on increasing compliance scores, decreasing IV medication errors, and improving patient safety.

The collection of various comments from the survey participants suggest that nurses have a great deal to say regarding Guardrails™ usage at the facility. Therefore, nursing leaders should conduct informal interviews with nursing end-users, as doing so, may offer further insights on barriers to the use of Guardrails™.

Conclusions

Adherence to Guardrails™ on smart pumps, ensuring that the drug libraries are updated frequently, and sharing each units ID number with all staff nurses, especially Meduflex (float pool nurses) in the event they would need to float to other units is warranted. Doing so, increases Guardrails™ compliance scores, decreases IV medication errors, and improves patient safety. However, nurses still fail to utilize the safety features. The evidence collected in this project provides data that support establishing an organized education program that aims to identify barriers to nurses’ use of Guardrails™ and increase nurses’ use of Guardrails™ in order to increase compliance scores over time. In

2010, the facility identified that nurses were utilizing Guardrails™ safety features <75% of the time. The facility then took the initiative to identify why the issue of noncompliance was occurring, implemented various interventions based on their findings, measured outcomes from their interventions, and finally adopted a continuous educational audit process that supported the hospital's culture. All interventions had a positive impact on increasing the institutions' averaged yearly compliance scores from 75% to 88%, and 90% as of September 2017.

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APPENDIX A

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To: info@peoplealchemy.co.uk
Subject: Copyright

Hi my name is Ivory Williams, and I was writing in reference to obtain your approval to use a design/figure that was created by one of your members on your website (see figure below). The design/figure incorporates Kurt Lewin's Change Management Theory, and I would like to use in my dissertation with your permission. I look forward to hearing from you soon.

Thank you,
Ivory

Change Design *by David King*

The Kurt Lewin change model

- Change Design
- Introduction
- In a nutshell
- Common questions
- Preparing for change
- Six-step cycle for planning change
- First things first
- The Kurt Lewin change model
- Exploring viewpoints
- Why-what-how hierarchy
- Developing a vision statement
- Blueprint models

Kurt Lewin describes three states that organisations go through:

- The cycle through each change state can be quite rapid.
- In modern businesses and organisations, the 'refreeze' state can transitory and brief, as the quest for improvement drives onwarc

From: Paul Matthews <paul.matthews@peoplealchemy.co.uk>
Date: October 18, 2017 at 16:03:24 EDT
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Dear Ivory,

You are very welcome to use the diagram in your dissertation.

I wish you luck with your qualification.

My best wishes, Paul

Learning Transfer - Employee Induction - Management Development - Performance Support

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