7-8-2020

Optimizing the Effectiveness of Peripheral Intravenous Catheters

Carrie Kollar
University of Missouri-St. Louis, cakce5@umsystem.edu

Optimizing the Effectiveness of Peripheral Intravenous Catheters

Carrie A. Kollar, MSN, RN, VA-BC, CNE

MSN-Ed, Central Methodist University, 2018

BSN, University of Missouri – St. Louis, 2008

ADN, Jefferson College – Hillsboro, 2000

A Dissertation Submitted to The Graduate School at the

University of Missouri – St. Louis

in partial fulfillment of the requirements for the degree of

Doctor of Nursing Practice

August 2020

Advisory Committee

Dr. Laura Kuensting, DNP, APRN, PCNS-BC, CPNP-PC, CPEN

Chairperson

Dr. Elizabeth Mantych, DNP, RN

Committee Member

Sharon Holtmeyer, MBA

Committee Member

Abstract

Problem Hospitalized adult patients require more than one short peripheral catheter (SPC) to complete the prescribed intravenous (IV) therapy due to catheter failure and the practice of resiting. The purpose of this quality improvement initiative was to increase the rate of SPCs remaining in situ for the entire duration of the IV therapy for hospitalized adult patients.

Methods Application of an engineered securement device (ESD), an educational program pertaining to modifiable risk factors, and changing the practice to removal upon clinical indication were methods utilized to reduce the number of SPC insertions and catheter failures. This study was conducted at a rural, Midwestern hospital using a convenience sample (*N*=405) and an observational, descriptive, cohort design in six phases between September 2019 and March 2020.

Results Following the practice changes, there was a reduction of SPC replacement (24%), catheter failures (24% to 13%), SPCs per patient (*M*=2.9 to 2.2 *p*=.045), SPC insertions (4,000 per year), and zero SPC-related CRBSIs (0.26 per 1000 catheter days to 0.0) and a significant increase of SPCs remaining in situ (*M*=2.6 to 3.8 days; p=<.001), resulting in an estimated cost saving of at least $285,000. The results demonstrated the risk of failure significantly increased when inserted in the wrist (*p*=.007) and upper arm (*p*=.026) and significantly reduced when inserted in the forearm (*p*=0.39).

Implications for Practice Study findings suggest the use of an ESD, promoting insertion in the forearm, avoidance of the wrist and upper arm, and the practice change to removal when clinically indicated.

Optimizing The Effectiveness Of Peripheral Intravenous Catheters

Short peripheral intravenous catheter (SPC) insertion is the most common invasive procedure performed in the hospital (Flippo & Lee, 2011). The intention of a SPC insertion is for less than 6-days of intravenous (IV) therapy to infuse fluids, blood products, medications, and contrast media directly into the circulatory system. An SPC is defined as a catheter less than three inches (7.5 cm) inserted into and terminating in the peripheral vein of an extremity (O'Grady et al., 2011). There are 330 million SPCs sold annually in the U.S. (Hadaway, 2012). Furthermore, approximately 60 to 90% of admitted patients in an acute care hospital are prescribed IV therapy requiring an SPC (Helm, Klausner, Klemperer, Flint, & Huang, 2015). Interestingly, SPCs do not remain in situ for the entire duration of the prescribed IV therapy for hospitalized adult patients. Tan, Tai, Sim, and Ng (2016) found an average rate of 2.82 SPC insertions per patient admission with an average of 29% failing and 14.9% resited although functioning and asymptomatic. Hence, approximately 44% of adult patients require more than one catheter during their hospital stay to complete the prescribed IV therapy.

A vascular access device (VAD) not remaining in situ for the entire intended duration due to complications is defined as a catheter failure. Undesirable high catheter failure rates between 16% and 70.7% causing a disruption in IV therapy has been reported in the literature (Rickard et al., 2018; Shears, 2006; Webster, Osborne, Rickard, & Marsh, 2019). SPCs have the highest rate of total complications compared to other VADs (Gunther et al., 2016). One failure initiates a cycle of catheter removal and reinsertion, further increasing the risk of failure with each subsequent attempt. Eventually, venous exhaustion occurs resulting in a more costly and higher risk VAD

being needed. Known VAD-related complications include phlebitis, infiltration, extravasation, infection, dislodgement, occlusion, and leakage with phlebitis and infiltration are reported as the most common causes of catheter failure (Helm et al., 2015).

Not only are patients receiving multiple SPCs due to catheter failure, but also because of the current practice of routine removal at timed intervals. Functioning, asymptomatic SPCs are being removed at designated intervals to insert a new catheter into another site, despite the Infusion Nurse Society (INS) recommendations. The INS recommended removal of a SPC when clinically indicated, meaning to remove when there are signs of VAD-related complications or the catheter is no longer needed (Gorski et al., 2016). In addition, the Centers for Disease Control and Prevention (CDC) updated the *Guidelines for the Prevention of Intravascular Catheter-Related Infections* to replace adult SPCs "no more frequently than every 72- to 96-hrs", allowing for extended dwell times (cited in O'Grady et al., 2011 p. 16). This statement is incongruent with the CDC recommendation for replacement of SPCs in the pediatric population specifically stating to "replace peripheral catheters in children only when clinically indicated" (cited in O'Grady et al., 2011, p. 16). High-quality systemic reviews of randomized control trials (RCTs) have demonstrated no increased risk of phlebitis, infection, infiltration, or occlusion, and a significant cost savings when SPC sites are changed at routine intervals compared to removal when clinically indicated (Morrison & Holt, 2015; Webster et al., 2019).

Currently, at a rural, Midwestern hospital, evaluating and changing SPC practices pertaining to stabilization and removal when clinically indicated have been identified as

an area of need. The purpose of this quality improvement (QI) initiative was to increase the rate of SPCs remaining in situ for the entire duration of the prescribed IV therapy for hospitalized adult patients. The aim of the project was to decrease SPC replacement by 15% within 6-months. The primary outcome measures of interest were the rate of SPCs inserted per patient and catheter failures. Secondary outcomes measures included rates of catheter-related bloodstream infections (CRBSI), gauge, location, stabilization technique, removal reason, site signs and symptoms, length of stay (LOS), and days in situ. The questions for study were: In hospitalized adult patients aged 18-years and older requiring a SPC,

1. how does the use of an engineered stabilization device compared to tape and a standard transparent dressing for stabilization affect the rate of SPC insertions and failures over 1-month intervals for a 6-month period?
2. how does replacing the catheter only when clinically indicated compared to replacing the catheter every 96-hrs affect the rate of SPC insertions over 1-month intervals for a 6-month period?

Literature Review

The search engines used for this literature review included EBSCO, CINAHL, PubMed, and Google Scholar and the Cochrane Central Register of Controlled Trials (CENTRAL). The key search terms were *securement, stabilization, dressing, clinically indicated, dwell, in situ, failure,* and *intravenous* AND *catheter* AND *peripheral*. A total of 89 publications were initially obtained. A refined search with inclusion criteria were peer-reviewed, full-text, and English-language publications from 1999 through 2019. Publications were excluded if not human-research, adult population, or SPC study.

Additionally, an ancestry approach to some references was utilized. Eleven studies from 2006 to 2018, addressing stabilization were selected including one systematic review, two integrative reviews, five RCTs, two prospective controlled cohort studies, and a retrospective cohort study. In addition, two systematic reviews from 2015 to 2019 addressing removal when clinically indicated were selected. The following themes organized the literature review: catheter failure, stabilization, and removal practices.

The high rate of SPC insertions per patient incurs unnecessary pain and anxiety while multiple attempts with each insertion further increases complications (Helm et al., 2015). Van Loon et al. (2019) found an 81% first attempt success rate for adult hospitalized patients. The average rate per insertion is between 2.18 and 2.35 attempts (Hadaway, 2012). Multiple needlesticks cause frustration for the patient and clinician, especially when resiting a functioning catheter. Helm et al. (2015) synthesized RCTs from 1990 to 2014 finding ranges of: phlebitis (0.1% - 63.3%), infiltration (15.7% - 33.8%), occlusion (2.5% - 32.7%), dislodgement (3.7% – 9.9%), and CRBSI (0.0% - 0.44%). The various complication rates were dependent on inclusion and exclusion criteria, definitions, indicators, and populations in each study.

Publications have shown significant correlations of specific modifiable risk factors (MRFs) contributing to catheter failure. A higher rate of phlebitis transpires with SPCs inserted in an area of flexion and high mobility such as the wrist, antecubital fossa (AC), hand (Wallis et al., 2014), or dominant extremity (Marsh et al., 2018). Large catheter diameters (Zhu, Wang, & Wen, 2016) increase the risk of phlebitis while a small catheter diameter increases the risk of dislodgement (Wallis et al., 2014) and infiltration (Marsh et al., 2018). Wallis et al. (2014) found upper arm SPCs increase the risk of

infiltration. Therefore, as demonstrated by Elia et al. (2011), upper arm SPCs have lower complication rates if longer than 5 cm (14%) compared to less than 5 cm (45%). The INS *Infusion Therapy Standards of Practice* recommended to (a) insert in the forearm and nondominant extremity, (b) avoid areas of flexion, (c) choose a 20- to 24-gauge for most IV therapies, (d) select a catheter of adequate length for deeper veins, and (e) consider a stabilization device (Gorski et al., 2016). DeRosenroll (2017) found educating clinicians about MRFs when selecting the location, laterality, and catheter gauge and length upon insertion will significantly affect outcomes including catheter failure.

Stabilization devices may minimize catheter micromotion in the vein reducing premature catheter failure and complications (Fourie, 2015; Marsh et al., 2018). Multiple products have been promoted for SPC stabilization, each providing a unique method of securement and cost. Multiple terminologies and synonyms have been utilized among researchers, clinicians, and professional organizations causing confusion and challenges when reviewing evidence. To provide clarity, SPC stabilization devices were defined and categorized into six types: *Tape* is used in conjunction with gauze or a non-bordered transparent dressing (*standard dressing* [SD]); a *bordered dressing* (BD) is a bordered transparent dressing; an *advanced securement dressing* (ASD) is a bordered transparent dressing with an integrated device for stabilization; an *engineered securement device* (ESD) is a device with anchor points or clips for stabilization and used in conjunction with an SD or BD; and a *tissue adhesive* is an adhesive such as glue applied topically in conjunction with an SD or BD. Stabilization device products discussed in the research include but are not limited to ESDs (Grip-Lok™, StatLock™, VITAL-HOLD™,

Hubguard™), BDs (Advanced Tegaderm™, Securis™, Veni-Gard™), an ASD (Sorbaview SHIELD™), and a TA (Hystacryl™).

The original stabilization technique, tape, has been found to increase the risk of contamination when retrieved from a pocket or adhered to a table prior to application (Morris & Tay, 2008). A large meta-analysis (N = 10,164) reported a new product established in 1996 (StatLock™) demonstrated reduced restart rates (67%) and a cost savings ($18,000 per hospital) compared to tape (Shears, 2006). Subsequently in 2006, the INS Standards stated to "consider an engineered stabilization device (ESD) to secure VADs" for the prevention of complications and dislodgement (Gorski et al., 2016, p. 73). StatLocks™ are also made for stabilizing other healthcare devices ranging from urinary catheters to drains. StatLocks™ continue to be the most commonly used VAD stabilization device globally. Since the introduction of the StatLock™, many types of stabilization devices have been manufactured, utilized, and researched. The Advanced Tegaderm™ with a winged catheter (WC) was compared to the StatLock™ with a standard catheter (SC) demonstrating similar failure rates and a cost savings of $2.57 per insertion with the Advanced Tegaderm™ (Delp & Hadaway, 2011). Studies comparing the Advanced Tegaderm™ with a SC or WC to a SD with a SC produced low-quality evidence (deRosenroll, 2017; Fourie, 2015; Jackson, 2012). Marsh, Webster, Flynn, and Mihala (2015) conducted a small RCT (N = 85) finding catheter failure rates highest with a SD (38%), BD (25%), ESD (22%), and TA (14%), respectively. TAs have shown to have antimicrobial properties inhibiting microbial growth (Simonova et al., 2012; Rickard et al., 2018), but caused skin tears, rashes, and blisters (Marsh, Webster, Flynn, et al., 2015). A comparison of the Advanced Tegaderm™ compared to a SD in a large

RCT (*N* = 628) demonstrated no difference in overall complications for patients (Gunther et al., 2016). A systematic review evaluated catheter failure identifying low-quality evidence that one product (SD, BD, or ESD) reduced complications or was superior (Marsh, Webster, Mihala, & Rickard, 2015). In 2018, a large RCT (*N* = 1807) comparing a BD, ESD, TA, and SD found no difference in failure rates and an actual cost savings with an SD (Rickard et al., 2018). Devries and Strimbu (2019) found over 3-years when using a BD with a WC there was, "difficulty maintaining a fully intact dressing" so the organization added a TA to significantly increase the rate of intact dressings from 55% to 98% (Devries & Strimbu, 2019, p. 88).

The 2016 INS Standards stated, "For peripheral catheters, consider two options for catheter stabilization" such as a WC with a BD or a SC with an ESD (cited in Gorski et al., 2016, p. 73). The INS Standards further reported a BD with a SC may increase in situ times, although further research was needed. The INS did not endorse one product, although recommendations to avoid tape, gauze, and SDs for securement due to ineffectiveness was specified (Gorski et al., 2016). This was interpreted as the reduction in failure rates was an affect of the catheter or securement device which must have an integrated stabilization, such as with an ASD, ESD, or WC.

There are many limitations and minimal strengths of recent SPC stabilization technique research. While most studies had a significantly reliable sample size, three did not report the sampling method or size (deRosenroll, 2017; Jackson, 2012; Marsh, Webster, Flynn, et al., 2015) and one RCT had a small sample size (Marsh, Webster, & Flynn, et al., 2015). Several studies had limited generalization when conducted in a single center (Fourie, 2015; Gunther et al., 2016; Marsh, Webster, Flynn, et al., 2015; Marsh,

Webster, Mihala, et al., 2015) and when inserted in the forearm at an unusually high rate (80%) (Rickard et al., 2018). No research investigators were blinded due to the nature of the research; therefore, information bias was a potential in every study. There was a high risk of bias when researchers received monetary compensation or funding from the product manufacturer(s) (Bausone-Gazda et al., 2010; deRosenroll, 2017; Flippo & Lee, 2011; Fourie, 2015; Jackson, 2012; Marsh, Webster, Mihala, et al., 2015).

In 1996, the CDC Guidelines were updated to reflect evidence-based research reflecting adult SPCs were to be removed no more frequently than "every 72- to 96-hrs" (cited in O'Grady et al., 2011 p. 16). Since then, many high-quality studies evaluating SPC in situ times and outcomes have been conducted. The Australian Access Teaching and Research Group (AVATAR) conducted a systematic review to examine the effects of removing SPCs routinely versus when clinically indicated finding no difference of phlebitis when removed upon clinical indication (9%) versus routine removal (7.2%) (Webster, Osborne, Rickard, & Hall, 2010). Based on the emerging evidence, in 2011, the INS Standards recommended removing SPCs when clinically indicated (Gorski et al., 2016). Furthermore, AVATAR conducted updated systematic reviews in 2010, 2013, 2015, and 2019 with the last review finding no difference in the in incidence of CRBSI, thrombophlebitis, all-cause BSI, mortality, or pain (Webster, Osborne, Rickard, & Marsh, 2019). In addition, there was moderate evidence of a $5 per patient cost savings with the clinically indicated group (Webster et al., 2019). Likewise, Morrison and Holt (2015) conducted a systematic review finding no difference in phlebitis or infection and reduced costs and time when practicing removal upon clinical indication.

In summary, recent research has not identified a superior SPC stabilization product to standardize practices which may contribute to the limitations of the SPC studies. This may be due to various study designs, additional variables affecting outcomes, and product research costs. Multiple interchangeable SPC insertion products have created a variation of combinations used outside and within organizations. There is a gap in the literature for large high-quality RCTs to evaluate the effects and cost of all stabilization techniques and to identify a superior device. Non-manufacturer grant funding may enable high-quality product research, potentially eliminating conflicts of interest and investigator bias. Furthermore, additional INS definitions of the different types of SPC stabilization devices and catheters is needed for researchers and clinicians to use consist language and have congruent interpretations of evidence when analyzing, disseminating, and implementing stabilization device research. Based on the evidence from the literature review, INS Standards, CDC Guidelines, the transition of practice from routine removal to when clinically indicated, and the addition of an evidence-based SPC stabilization technique has been recommended to reduce costs and prevent catheter failures.

The Iowa Model of evidence-based practice to promote quality care, created by the University of Iowa Hospitals and Clinics, was utilized as the framework for this QI initiative (Iowa Model Collaborative, 2017). The Iowa Model employs a system's perspective to guide clinical decisions when transitioning evidence into practice by identifying issues, researching solutions, and implementing changes (Iowa Model Collaborative, 2017). This model begins with the identification of the topic in question being a problem-focused trigger or a knowledge-focused trigger before the purpose or

question(s) for study are formulated. Once the problem, purpose, and practice question(s) are considered a priority for the organization, the QI process begins.

Methods

Design

An observational, descriptive, cohort design was utilized. A retrospective medical record review was the primary method of data collection. The QI initiative was implemented in six phases over a 6-month period. Baseline data collection began September 15th, 2019 during Phase 1 (P1). A nursing education program regarding MRFs and implementation of an ESD was completed in the designated trial departments in Phase 2 (P2) starting November 19th, 2019. Patients with a documented or known contraindication or sensitivity to the ESD had tape and a SD or gauze applied as an alternative. A nursing education program regarding SPC care and maintenance and a practice change to clinically indicated was completed in the designated trial departments in Phase 3 (P3) beginning December 5th, 2019. In addition, simultaneously, applicable departments received the MRFs and ESD education for implementation hospital-wide. In Phase 4 (P4), education regarding SPC care and maintenance and a practice change to clinically indicated was implemented hospital-wide starting January 1st, 2020. The practice change to clinically indicated was implemented February 3rd, 2020 in Phase 5 (P5). Finally, beginning March 5th, 2020 education and outcomes from the previous phases was reinforced in Phase 6 (P6).

Setting

The setting was a rural, Midwestern hospital employing more than 1,500 employees with approximately 127 outpatient clinic physicians affiliated with the

hospital across 24 specialty areas (Mercy, 2019a). Each year, there are over 38,000 emergency department (ED) visits; 5,900 acute inpatient discharges; and 12,000 inpatient and outpatient surgeries performed at the hospital (Mercy, 2019a). This hospital is part of a multicenter healthcare organization with 30 acute care hospitals throughout four states in the Midwest region (Mercy 2019b). The hospital services about 180,000 patients living and working in the surrounding 17 cities. The county of origin has a population of slightly over 14,000 with a poverty rate (8.5%) below the state rate of 14.6% and with a majority race being white (93.3%), which is higher than the state rate of 79.8% (U.S. Census Bureau, n.d.).

Approval Processes

The Chief Nursing Officer (CNO) and President of the hospital approved the primary investigator (PI) to facilitate and initiate this QI initiative in collaboration with the Infection Control nurse. In addition, the university's doctor of nursing practice (DNP) committee, institutional review board (IRB), and the hospital's IRB granted approval. Benefits of this study included contributions to the decision-making about best practice for the hospital regarding SPCs. There was minimal risk to subjects as all patient identifiers of the data were removed and this was a retrospective analysis of nursing practice.

Sample

A convenience sample of SPCs inserted in adult patients admitted to the hospital was used in each phase. Inclusion criteria consisted of SPCs in adult patients 18-years of age or older admitted to the hospital, regardless of diagnosis or medications. Exclusion criteria consisted of SPCs inserted in pediatric patients 17-years of age or younger

admitted to the hospital, outpatients including clinic and ED patients who were not admitted, prehospital insertions, and labor and delivery inpatients.

Data Collection/Analysis

All data was acquired from an SPC audit instrument developed by the PI for QI. Demographic information was not collected. The rate of SPCs inserted per patient and catheter failure rates was obtained. Other data included SPC stabilization technique, gauge, location, removal reason, days in situ, site signs and symptoms, LOS, and CRBSI. The electronic medical record (EMR) provided six options for the removal reason: per policy, no longer indicated, site symptoms, per patient, per order, and observed not present. All data was stored on a password protected computer. Data collection included a visual site audit completed in a single day at least 4-days after the initiation of each phase and a chart audit was conducted in a single day at least 7-days following each visual site audit. Descriptive statistics and statistical analysis using chi-square, Fischer's exact, binary logistic regression, ANOVA, and *t*-tests were conducted based on an alpha value of $p < .05$. Failure rates were defined as SPCs categorized as yes for the site signs and symptoms group or categorized as site symptoms for the removal reason group. The yes category included observations of erythema, swelling, pain, warmth/cool, and purulent drainage when observed during the visual audit. The blood category in the site signs and symptoms group was defined as observed dry or aqueous blood extending beyond the insertion site.

Procedures

This QI initiative practice interventions were systematically developed using a plan-do-study-act (PDSA) cycle plan and a timeline. A root cause analysis using a fish-

bone diagram identified the cause and effects of multiple SPCs per patient (Appendix A). An evaluation of the hospital's current practices and the system's other four hospitals in a geographic location was undertaken including identification of products, policies, procedures, documentation, and reporting practices. For the past 2-years, the wound care specialist performed VAD audits with the assistance of wound care champions while completing quarterly wound prevalence audits. A pareto chart was devised based on the audit results (Appendix B). A formal meeting with key stakeholders was employed to engage the participants, present the plan, decide on a stabilization product and maintenance practices, and eliminate barriers. The key stakeholders assessed the stabilization technique options and decided to utilize the StatLock™ ESD for stabilization based on the literature review. Educational material was developed and delivered through multiple teaching strategies including a printed bulletin and a 5-minute roving demonstration. Content included MRFs affecting failure, application and removal of the ESD, maintenance, and removal procedures. Leadership announced the implementation dates and the product was stocked and available. A formal meeting was scheduled after each phase for key stakeholders to collaboratively evaluate and analyze the data, assess the implementation process, identify what was learned, review compliance, and decide to adopt, adapt, or abort the interventions.

Results

Between September 15th, 2019 and March 18th, 2020, there were 339 patients with one or more SPCs (N=405) secured with a SD (n=218) and an ESD (n=187). The SD category had failure in 19% (n=40) compared to 12% (n=23) in the ESD category. A chi-square test of independence was conducted to examine whether failure and stabilization

technique were independent of each other. The results were not significant at the .05 level (χ^2=2.80, *df*=1, *p*=.094), suggesting failure and stabilization technique were likely independent of one another.

During P1 (baseline data), the mean number of SPCs per patient was 2.90 (*SD*=2.11). Education pertaining to MRFs and stabilization techniques was given to inserters and the ESD was supplied after baseline data collection in P1. A two-tailed independent samples *t*-test was conducted to examine the rate of SPC per patient difference between the SD category (*n*=66) and the ESD category (*n*=82) during P2 and P3. The mean number of SPCs per patient for the SD category was 2.78 (*SD*=2.19) and was significantly higher than the mean for the ESD category 2.08 (*SD*=1.26) at the .05 level (*t*=2.32, *df*=146, *p*=.021). The number of SPCs per patient was significantly different between stabilization techniques in P2 and P3, indicating the ESD was more stabilizing than the SD and resulted in a lower number of SPC restarts.

Likewise, a two-tailed independent samples *t*-test was conducted to examine the difference between the number of SPCs per patient from P4 through P6 when the practice of clinically indicated was implemented hospital-wide. The mean number of SPCs per patient for the P4 category was 2.29 (*SD*=1.28) when compared to the P6 category (*M*=2.22, *SD*=1.32) and was not statistically significant at the .05 level (*t*=0.30, *df*=119, *p*=.767). There was essentially no difference in the number of SPCs per patient between P4 and P6 despite practicing removal only when clinically indicated.

Next, a two-tailed independent samples *t*-test was conducted to examine if there was a difference in the mean number of SPCs per patient between P1 (*n*=49) and P6 (*n*=82). The analysis was conducted to evaluate the effect of implementing the

cumulative SPC education and interventions hospital-wide. The P1 category (*M*=2.90, *SD*=2.11) had a higher rate of SPCs per patient compared to the P6 category (*M*=2.22, *SD*=1.32) and was statistically significant at the .05 level (*t*=2.03, *df*=102, *p*=.045). The number of SPCs per patient was significantly reduced in P6 following the cumulative interventions throughout the previous five phases. A trending decrease of SPCs per patient occurred after P1 (*M*=2.90, *SD*=2.11) and continued through P6 (*M*=2.37 [*SD*=1.81]; 2.37 [1.76]; 2.29 [1.28]; 2.35 [2.16]; and 2.22 [1.32], respectively) (Appendix C).

The mean days in situ was 3.11 (*SD*=2.35) for a total of 1,258 catheter days. The days in situ increased from P1 (*M*=2.63, *SD*= 1.48) to P6 (*M*=3.74, *SD*=3.20) correlating to an average of each SPC in situ for one additional day. An ANOVA was conducted to determine whether there was a significant difference of days in situ by stabilization technique. The results indicated no significant difference ($F[1, 403] = 3.37$, $p = .067$). The mean days in situ of the ESD category was 3.34 (*SD*=2.58) and was greater than the SD category (*M*=2.91, *SD*=2.12). An ANOVA with Tukey pairwise comparisons was conducted to determine whether there was a significant difference of days in situ by phase. The results indicated a significant difference ($F[5, 399] = 5.09$, $p < .001$) of days in situ among the phases with P5 and P6 significantly higher than P2. The highest rate of failures for the in situ group occurred in the zero to 1-day category (*n*=20, 20%). The failure rate in the 2- to 4-day category was *n*=33 (15%), the 5- to 8-day category was *n*=7 (10%), and the 9- to 25-day category was *n*=3 (21%). Furthermore, 53 of 63 (84%) failed SPCs had failed when in situ less than 4-days. Of note, seven of 40 (18%) patients with a LOS 1-day or less required more than one SPC.

Analysis of site location demonstrated overall selection in the hand was 37 (9.14%), wrist (*n*=37, 9.14%), forearm (*n*=147, 36.3%), antecubital ([AC], *n*=154, 38.02%), and upper arm (*n*=28, 6.91%). An increase in forearm selection from P1 (*n*=16, 33%) to P6 (*n*=38, 46%) was observed, although the most frequently observed location was AC (*n*=154, 38%). A chi-square test of independence was conducted to examine whether location and phase were independent of each other. The results were not significant at the .05 level (χ^2=26.68, *df*=20, *p*=.145), suggesting location and phase were likely independent of one another. Therefore, there was not a significant change in the selection of location following the MRF educational program. A binary logistic regression was conducted to examine the effect of location on failure rates. The regression coefficient for the upper arm location was significant (*B*=1.15, OR=3.17, *p*=.026). Failure was likely in the upper arm at 217%. The regression coefficient for the wrist location was also significant (*B*=1.26, OR=3.52, *p*=.007). A failure was likely in the wrist at 252%. A chi-square test of independence was conducted to examine if failure and location were independent of each other. The relationship between location and failure rate was statistically significant at the 0.05 level (χ^2=10.08, *df*=4, *p*=.039). Hence, location was related to failure rates. SPCs in the forearm had a lower observed failure rate (*n*=14) than expected failure rate (*n*=22.62) compared to the hand (*n*=7, 5.6), wrist (*n*=10, 5.69), AC (*n*=24, 23.69), and upper arm (*n*=7, 4.31). In addition, the days in situ time was greater when in the forearm (*M*=3.44, *SD*=2.92).

The catheter gauges used were 16 (*n*=3, 0.74%), 18 (*n*=57, 14.07%), 20 (*n*=325, 80%), and 22 (*n*=20, 4.94%). The 20-gauge catheter was the most frequently

used catheter size with a steady increase in use from P1 (*n*=37, 76%) to P5 (*n*=50, 83%), but a decreased rate of use occurred in P6 (*n*=62, 76%). Also, 14 of 57 (25%) 18-gauge catheters were inserted in the hand and wrist. The days in situ for each gauge catheter were 16 (*M*=3.33, *SD*=0.58), 18 (*M*=2.77, *SD*=1.76), 20 (*M*=3.13, *SD*=2.43), and 22 (*M*=3.70, *SD*=2.64). Interestingly, the mean days in situ was greatest for 22-gauge catheters (*M*=3.70, *SD*=2.64). A Fischer's exact test was conducted to examine whether the rate of gauge and phase were independent of each other. The results were not significant at the .05 level (*p*=.300), suggesting the rate of gauge and phases were likely independent of one another. Therefore, there was not a significant change in the selection of gauge following the MRF educational program. A Fischer's exact test was also conducted to examine whether the rate of gauge and failure were independent of each other. The results were not significant at the .05 level (*p*=.857), suggesting the rate of gauge and failure were likely independent of one another. A binary logistic regression was conducted to examine whether gauge had a significant effect on failure rates. The results were not significant (χ^2=1.30, *df*=3, *p*=.728) suggesting gauge did not have an effect on failure.

In the site signs and symptoms group, there was a low frequency in the yes category (*n*=7, 1.73%) and a high frequency in the blood category (*n*=130, 32.1%). The frequency in the blood category significantly decreased from P1 (*n*=30, 42%) to P6 (*n*=14, 17%). A Fischer's exact test was conducted to examine whether the rate of site signs and symptoms and phase were independent of each other. The results were significant at the .05 level (*p*=.012), suggesting the rate of site signs and symptoms and phases were likely not independent of one another. A lower than expected rate of the

blood category was observed in P3 (24[24.40]), P4 (17[21.19]), and P6 (12[26.32]) and a lower than expected rate of the yes category was observed in P2 (1[1.24]), P3 (1[1.31]), P4 (0[1.14]), and P5 (1[1.04]).

The most frequently observed category in the reason for removal group was no longer indicated (*n*=145, 36%) compared to per policy (*n*=35, 9%), site symptoms (*n*=63, 16%), per patient (*n*=17, 4%), per order (*n*=2, 1%), observed not present (*n*=6, 2%), not documented but removed at discharge (*n*=117, 29%), not documented thus removal unknown (*n*=20, 5%) (Appendix D). Unfortunately, 137 (34%) of the SPCs did not have a removal reason documented. A removal time was documented in 117 (85%) of the 137 SPC's within 2-hrs of being discharged; hence, the reason for removal due to discharge was assumed. The rate of the site symptoms category immediately decreased from 24% to 14% after implementing the ESD.

The population's mean LOS (*M*=4.77 days) (Appendix E) was greater compared to the organization's reported mean from September 2019 to March 2020 (*M*=2.88 days). The difference was expected due to the exclusion of labor and delivery patients. There were 66 (16.3%) patients who had two SPCs concurrently, commonly due to incompatible or multiple IV infusions. In addition, 34 of 339 (10%) patients required a central IV catheter during their hospitalization. The number of central IV catheters inserted per patient decreased from P1 (*n*=6, 16%) to P6 (*n*=5, 8%) during the 6-month study period. A chi-square test of independence was conducted to examine whether the rate of central IVs and phase were independent of each other. The results were not significant at the .05 level (χ^2=2.63, *df*=5, *p*=.757), suggesting the rate of central IVs and

phases were likely independent of one another. Finally, the hospital's total number of CRBSI was zero during the 6-month period from P1 through P6.

Discussion

In hospitalized adult patients aged 18-years and older requiring a SPC, replacing the catheter only when clinically indicated compared to replacing the catheter every 96-hrs did affect the rate of SPC insertions over 1-month intervals for a 6-month period. The P1 group had a higher rate of SPCs per patient compared to the P6 group (p=.045). The number of SPCs required per patient was significantly less in P6 after education of stabilization techniques and implementation of clinically indicated changing of an SPC throughout the previous five phases. A steady trending decrease of SPCs per patient occurred after P1 from an average 2.9 SPCs per patient to 2.37 SPCs per patient in P6. Regardless of the initial hospital policy of routine replacement at 96-hrs, some SPCs were remaining in situ longer than 96-hrs prior to implementing a formal practice change to remove only if clinically indicated. After the practice change, however, the rate of SPCs in situ after 96-hrs steadily increased from 8% (P1) to 29% (P6). This rate was comparable to the previously cumulative reported rates of SPCs resited plus SPCs remaining in despite organizational policies to resite (28.3%). The practice change from P3 to P6 when hospital-wide implementation occurred, provided a 20% reduction rate of at least one SPC for patient's hospitalized between 5- and 8-days, and a 9% reduction rate of more than one SPC for patient's hospitalized more than 8-days. Interestingly, one SPC stabilized with an ESD remained in situ for 25-days in P6, preventing an estimated six SPCs for one patient (Appendix F).

In hospitalized adult patients aged 18-years and older requiring a SPC, the use of an ESD compared to tape and a SD for stabilization affected the rate of SPC insertions and failures over 1-month intervals for a 6-month period. The baseline rate of 2.9 SPCs per patient during P1 was comparable to the rate previously reported but significantly higher than the 2.29 rate in P4 acquired before implementing the practice change to clinically indicated and the 2.22 rate acquired by the end of P6 (p=.05). When the ESD was introduced, the average number of SPCs per patient for the SD category (2.78) was significantly higher (p=.021) than for the ESD category (2.08). In contrast, implementing the practice change to clinically indicated did not result in a significant difference (p=.767) in the average number of SPCs per patient in P4 (2.29) compared to P6 (2.22). Despite statistical insignificance, the average number of SPCs per patient was reduced between P4 and P6. In fact, a downward trend in the number of SPCs per patient over time occurred when the ESD and practice change for removal only if clinically indicated were implemented.

The number of SPCs stabilized with an ESD slightly increased during the study period. Stabilization selection was at the discretion of the insertor and the majority were inserted in the ED. Insertors were advised to utilize a SD on ED patients not admitted and surgical patients with less than an expected 24-hr LOS. The rate of failures decreased from 24% to 14% immediately after implementing the use of an ESD and MRF education. The failure rates were lower than previously reported failure rates. The failure rates are affected by documentation of the removal reason that is based on nursing selection and is not always complete. This may have contributed to the statistically insignificant association of stabilization and failure rates. The decreased failure rate, the

second highest rate of failure occurring in the 0- to 1-day in situ category (20%), and the rate of patients with a less than 24-hr LOS requiring more than one SPC (18%) support the use of an ESD for all SPCs including those intended to remain in situ less than 1-day. There is an opportunity to educate SPC insertors about the increased risk of failure with using a SD and to promote the usage of an ESD. Consideration for SPC policies to require an ESD for all inpatients is recommended.

While insertors select the location and gauge, further education is recommended to address the increased risk of failure when inserted in the upper arm (p=.026) and wrist (p=.007) and the statistically significant reduced risk of failure when inserted in the forearm (p=0.39). A high rate of insertions in the AC (38%) may have occurred due to a misunderstanding that a power injection procedure for computed tomography (CT) imaging studies must require an AC SPC, although this was addressed during P1 nursing education. Clarification within organizational policy was addressed to ensure adherence to the INS Standards and the American College of Radiology suggesting a large forearm vein was adequate. The result of the 22-gauge SPC having the highest in situ time (3.70 days) was inconsistent with the previously reported higher risk of dislodgement infiltration, although consistent with the INS Standards. Midline catheters were not inserted before or during the study period and may have contributed to the rate of central IV catheters and upper arm SPCs. Midline catheter insertions are being considered for future implementation. However, there is not a designated vascular access team or nurse employed at the hospital and may be need to be a consideration. Currently, the critical care and ED nurses are consulted for difficult SPC insertions. Perhaps a vascular access nurse may enhance the insertion of midline catheters and prevent the need for central IV

catheters. The MRFs educational program most likely did not affect the number of SPCs per patient and the failure rates due to the rate of selecting gauge and location was insignificantly different among all phases.

Infection is a potential complication from an SPC. While all SPCs had an attached extension, bonded needleless connectors were substituted with nonbonded needleless connectors to allow for changing the needleless connector prior to the practice change of removal when clinically indicated. During the study period, none of the SPCs remaining in situ beyond 7-days had documentation of the dressing, stabilization technique, and needleless connector being changed. While there is an opportunity for further education pertaining to documentation of SPC care and maintenance, astonishingly, the number of CRBSI was zero when compared to the previous fiscal year (0.26 per 1000 catheter days). Several factors may have contributed to the zero rate of CRBSI including a Hawthorne effect, reduction of SPC insertions, introduction of a no-touch antiseptic prep in the ESD kit, and reduced micromotion when using an ESD. The reduced CRBSI rates occurred prior to implementation of the interventions, therefore, are most likely the result of a Hawthorne effect. Regardless, removing a SPC only when clinically indicated did not increase the rate of CRBSI, and remarkably, produced no infections over a 6-month period. Further study over a longer period of time or a replication of this study is suggested.

No SPC major adverse events, skin tears, or allergic reactions were reported during the study period. Additional SPC practices thought to negatively affect the outcomes were addressed throughout the phases of the project including: (a) correct use of an ESD; (b) avoidance of a restrictive dressing (e.g. Coban™) or blood pressure cuff

on the SPC extremity; (c) netting (e.g. Surgilast™) utilized to reduce accidental dislodgement; (d) securement of the extension set to the skin; (e) and the avoidance of tape on the catheter hub to prevent improper downward angle, kinking, and occlusion of the catheter when using an ESD. Thus, over a 6-month period, no additional adverse events were reported, suggesting intensive education with a careful, methodical approach to reducing the number of SPCs was effective.

A major strength of this project was reliability as one individual collected all data. In addition, the PI did not receive monetary compensation from the organization or manufacturer, thus producing a low risk of bias. A limitation of this project was the potential overlapping of interventions during phases of the analysis. Recommendations for future research in SPC stabilization techniques include exploring the effect of the multiple interchangeable SPC products to identify a superior SPC product combination to standardize practices. High-quality product research funded by a non-manufacturer may potentially eliminate conflicts of interest and investigator bias. The effect of utilizing an ESD for SPCs intended to in situ for patients with a less than 24-hr LOS merits further investigation. Analysis of staff and patient satisfaction of SPC insertion, care, and maintenance may provide insight to opportunities for improvement. Furthermore, future research evaluating the insertor's reason for location and gauge selection may identify effective strategies for increasing the use of MRFs to improve outcomes.

Finally, the project aim to decrease SPC replacement by 15% within 6-months was exceeded as a reduction of 24% in SPC replacement occurred. A cost-benefit analysis demonstrated this QI initiative may have reduced the number of SPCs by approximately 4,000 per year. A total savings of at least $285,518 per year related to SPC

insertion reduction efforts may be realized, including the cost savings realized in the reduction of CRBSIs.

Conclusion

The combination of using an ESD and practice protocol of replacing SPCs only when clinically indicated resulted in a 24% reduction in the number of SPCs per patient and an 11% reduction in the number of catheter failures in a moderately sized, rural Midwestern hospital. Furthermore, there were no reported cases of CRBSI during the 6-month study period. This project promoted safe clinical care, decreased the use of resources, reduced the disruption of therapy, prevented unnecessary venipunctures, and resulted in improved outcomes. Since the insertion of an SPC is the most common, invasive procedure performed in the hospital, interventions to reduce complications should be a priority for any hospital organization.

References

Bausone-Gazda, D., Lefaiver, C.A., & Walters, S. (2010). A randomized controlled trial to compare the complications of 2 peripheral intravenous catheter-stabilization systems. *Journal of Infusion Nursing, 33*(6), 371-384. doi:10.1097/NAN.0b013e3181f85be2

Delp, J., & Hadaway, L. (2011). New product decisions – The Process and outcome for a community health system. *Journal of the Association for Vascular Access, 16*(2), 74-84. doi:10.2309/java.16-2-4

deRosenroll, A. (2017). Peripheral intravenous catheters: Improving outcomes through change in products, clinical practice and education. *Vascular Access, 11*(1), 7-12. Retrieved September 24th, 2019 from http://cvaa.info/Portals/0/Journal/Individual%20Articles/Articles%20with%20Cover%20Page/11-1%20deRosenroll.pdf

Devries, M., & Strimbu, K. (2019). Short peripheral catheter performance following adoption of clinical indication removal. *Journal of Infusion Nursing, 42*(2), 81-90. doi:10.1097/NAN.0000000000000318

Elia, F., Ferrari, G., Molino, P., Converso, M., Filippi, G.D., Milan, A., & Apra, F. (2012). Standard-length catheters vs long catheters in ultrasound-guided peripheral vein cannulation. *American Journal of Emergency Medicine, 30*, 712-71. doi:10.1016/j.ajem.2011.04.019

Flippo, P.L., & Lee, J. (2011). Clinical evaluation of the Sorbaview SHIELD securement device used on peripheral intravenous catheters in the acute care setting. The *Journal of the Association for Vascular Access, 16*(2), 1-7. doi:10.2309/java.16-2-6

Fourie, A. (2015). Peripheral intravenous catheter performance: Investigating peripheral intravenous catheter dwell times. *Professional Nursing Today, 19*(3), 7-11. Retrieved September 24th, 2019 from https://journals.co.za/docserver/fulltext/mp_pnt/19/3/mp_pnt_v19_n3_a4.pdf?expires=1571799576&id=id&accname=guest&checksum=BB734761714DF7B3BFAFE23647FB275C

Gorski, L., Hadaway, L. Hagle, M.E., McGoldrick, M., Orr, M., & Doellman, D. (2016). Infusion therapy standards of practice [Supplemental material]. *Journal of Infusion Nursing, 39*(1), S1-S159.

Gunther, S.C., Schwebel, C., Hamidfar-Roy, R., Bonadona, A., Lugosi, M. Ara-Somohano, C. … Timsit, J. (2016). Complications of intravascular catheters in ICU: Definitions, incidence, and severity: A randomized controlled trial comparing usual transparent dressings versus new-generation dressings (the ADVANCED study). *Intensive Care Medicine*, *42*, 1753-1765. doi:10.1007/s00134-016-4582-2

Hadaway, L. (2012). Short peripheral intravenous catheters and infection. *Journal of Infusion Nursing, 35*(4), 230-240. doi:10.1097/NAN.0b013e31825af099

Helm, R.E., Klausner, J.D., Klemperer, J.D., Flint, L.M., & Huang, E. (2015). Accepted but unacceptable: Peripheral IV catheter failure. *Infusion Nurses Society, 38*(3), 189-203. doi:10.1097/NAN.0000000000000100

Iowa Model Collaborative. (2017). Iowa model of evidence-based practice: Revisions and validation. *Worldviews on Evidence-Based Nursing, 14*(3), 175-182. doi:10.1111/wvn.1222

Jackson, A. (2012). Retrospective comparative audit of two peripheral IV securement dressings. *British Journal of Nursing, 21*(2), 16-20. doi:10.12968/bjon.2012.21.Sup1.S10

Marsh, N., Webster, J., Flynn, J., Mihala, G., Hewer, B., Fraser, J., & Rickard, C.M. (2015). Securement methods for peripheral venous catheters to prevent failure: A randomized controlled pilot trial. *The Journal of Vascular Access, 16*(3), 237-244. doi:10.5301/jva.50000348

Marsh, N., Webster, J., Mihala, G., & Rickard, C.M. (2015). Devices and dressings to secure peripheral venous catheters to prevent complications. *The Cochrane Database of Systematic Reviews, 6,* 1-56. doi:10.1002/14651858.CD011070.pub2

Mercy. (2019a). *Mercy Hospital Washington Quick Facts.* Retrieved September 3, 2019 from https://www.mercy.net/newsroom/mercy-hospital-washington-quick-facts/

Mercy. (2019b). *Mercy Quick Facts.* Retrieved September 3, 2019 from https://www.mercy.net/newsroom/mercy-quick-facts/

Morris, W., & Tey, M.H. (2008). Strategies for preventing peripheral intravenous cannula infection [Supplement]. *British Journal of Nursing, 17*(19), 14-21 doi:10.12968/bjon.2008.17.Sup8.31470

Morrison, K., Holt, K. (2015). The effectiveness of clinically indicated replacement of peripheral intravenous catheters: an evidence review with implications for clinical practice. *Worldviews on Evidence-Based Nursing, 12*(4). 187-198. doi:10.1111/wvn.12102.

O'Grady, N.P., Alexander, M., Burns, L.A., Dellinger, P., Garland, J., Heard, S.O., … The Healthcare Infection Control Practices Advisory Committee. (2011).

Guidelines for the prevention of intravascular catheter-related infections. *Clinical Infectious Disease: An Official Publication of the Infectious Disease Society of America, 52*(9), 1-83. doi:10.1093/cid/cir257

Rickard, C.M., Marsh, N., Webster J., Runnegar, N., Larsen, E., McGrail, M.R., … Playford, E.G. (2018). Dressings and securements for the prevention of intravenous catheter failure in adults (SAVE): A pragmatic, randomized controlled, superiority trial. *The Lancet, 392*, 419-430. doi:10.1016/S0140-6736(18)31380-1

Shears, G.J., (2006). Summary of product trials for 10,164 patients: Comparing an intravenous stabilizing device to tape. *Journal of Infusion Nursing, 29*(4), 225-231.

Simonova, G., Rickard, C.M., Dunster, K.R., Smyth, D.J., McMillan, D., & Fraser, J.F. (2012). Cyanoacrylate tissue adhesives - effective securement technique for intravascular catheters: In vitro testing of safety and feasibility. *Anesthesia and Intensive Care, 40*(3), 460-466. doi:10.1177/0310057X1204000311

Tan, Y.H.G., Tai, W.L.S., Sim, C., & Ng, H.L.I. (2016). Optimizing peripheral venous catheter usage in the general inpatient ward: A prospective observational study. *Journal of Clinical Nursing, 26*, 133-139. doi:10.1111/jocn.13451

U.S. Census Bureau. (n.d.). *Quick Facts: Franklin County, Missouri; Missouri; Washington city, MO.* Retrieved September 3, 2019 from https://www.census.gov/quickfacts/fact/table/franklincountymissouri,MO,washingtoncitymissouri/PST045218

van Loon, F.H.J., van Hooff, L.W.E., de Boer, H.D., Koopman, S.S.H.A., Buise, M.P., Korsten, H.H.M., …Bouwman, A.R.A. (2019). *Journal of Clinical Medicine, 8*, 144. doi:10.3390/jcm8020144

Wallis, M.C., McGrail, M., Webster, J., Marsh, N., Gowardman, J., Playford, G., & Rickard, C.M. (2014). Risk factors for peripheral intravenous catheter failure: A multivariate analysis of data from a randomized controlled trial. *Infection Control and Hospital Epidemiology, 35*(1), 63-68. doi:10.1086/674398

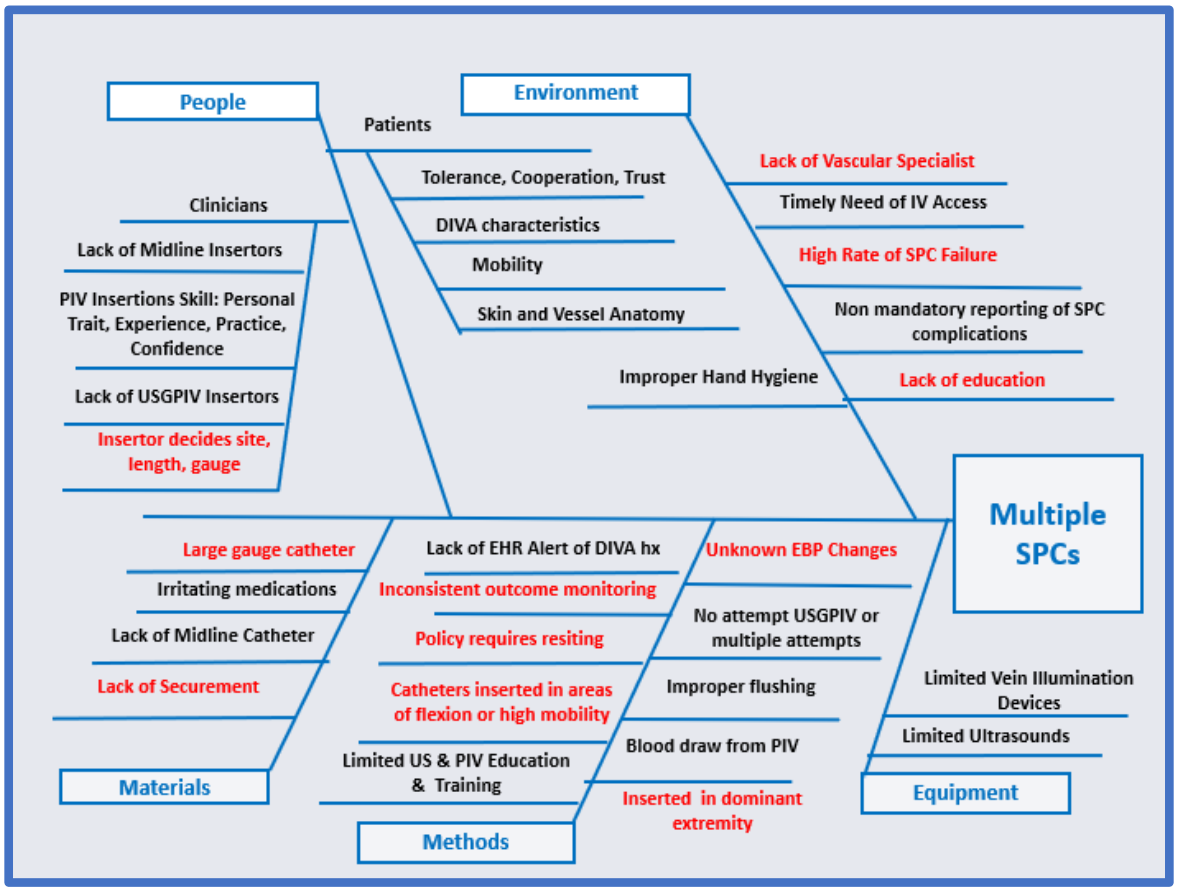
Webster, J., Osborne, S., Rickard, C.M., & Hall, J. (2010). Clinically-indicated replacement versus routine replacement of peripheral venous catheters. *The Cochrane Database of Systematic Reviews, 3*, 1-39. doi:10.1002/14651858.CD007798.pub2

Webster, J., Osborne, S., Rickard, C.M., & Marsh, N. (2019). Clinically-indicated replacement versus routine replacement of peripheral venous catheters. *The Cochrane Database of Systematic Reviews*, *1*, 1-55. doi:10.1002/14651858.CD007798.pub5

Zhu, A., Wang, T., & Wen, S. (2016). Peripheral intravenous catheters in situ for more than 96h in adults: What factors affect removal? *International Journal of Nursing Practice, 22*, 529-537. doi:10.1111/ijn.12492

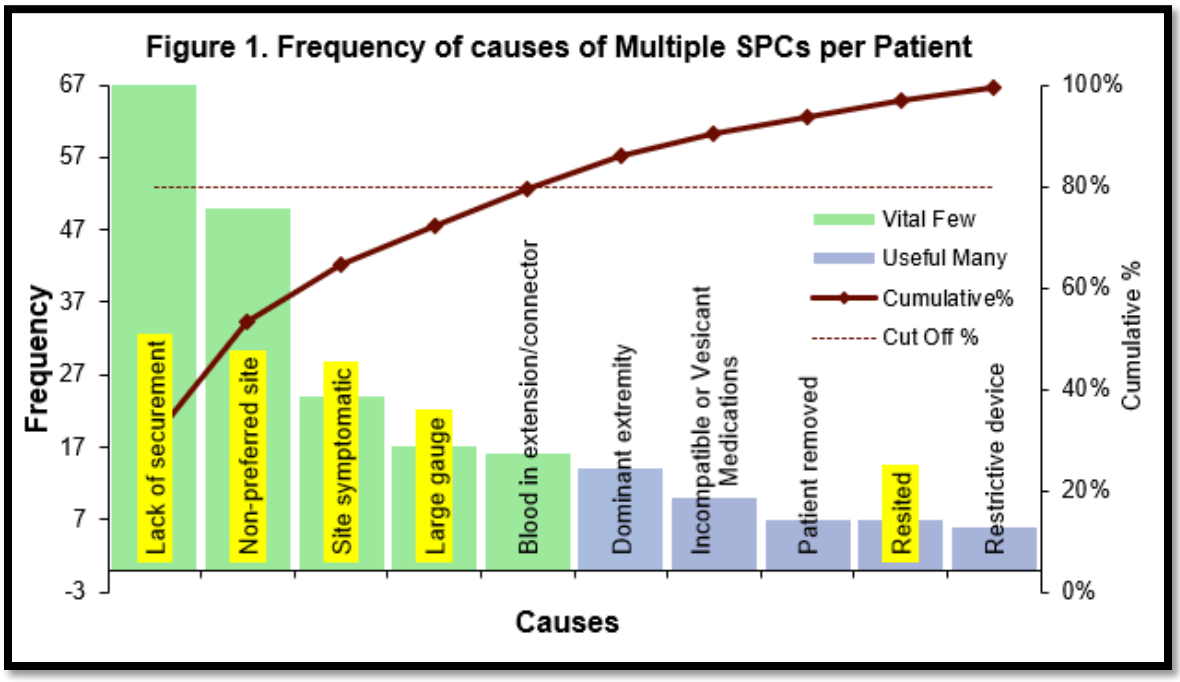
Appendix A

Figure 1. Root Cause Analysis for Cause and Effect Diagram of Multiple SPCs



Appendix B

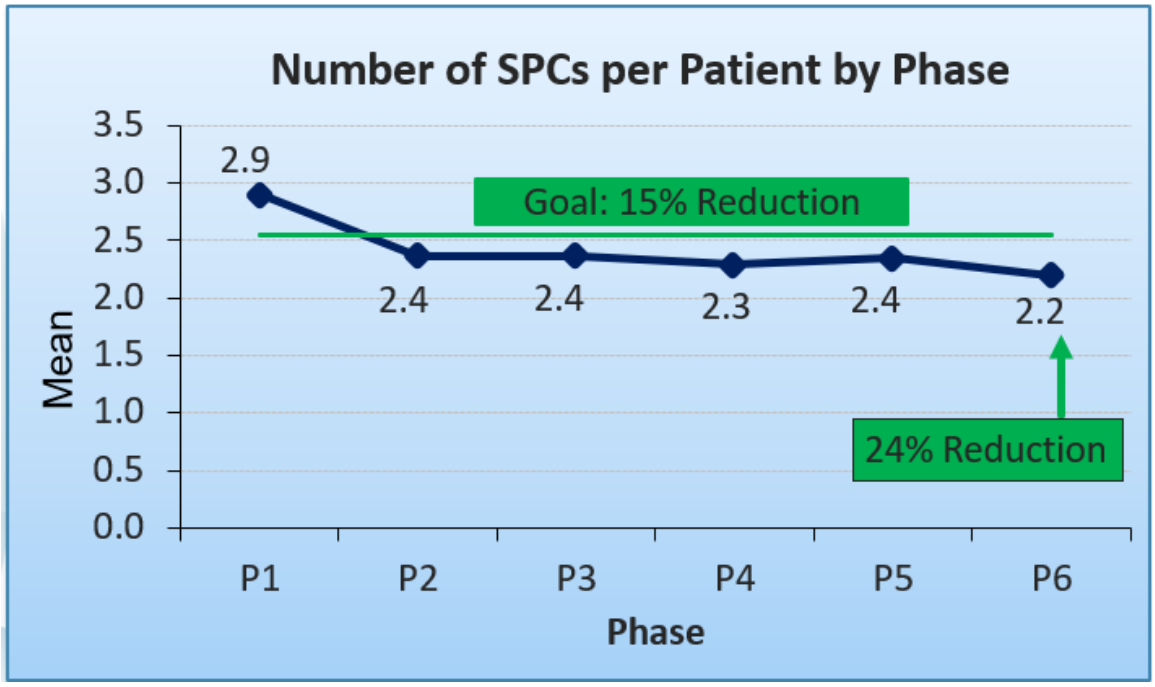
Figure 2. Frequency of Causes for Multiple SPCs per Patient



*Causes addressed with study interventions are highlighted

Appendix C

Figure 3. Summary Results of Number of SPCs per Patient by Phase



Appendix D

Table 1. *Summary Results of Phases*

Variable	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	n	%
Sample Size	49 (12%)	72 (18%)	76 (19%)	66 (16%)	60 (15%)	82 (20%)	405	100
Stabilization Technique								
SD	49 (100%)	38 (53%)	44 (58%)	26 (39%)	28 (47%)	33 (40%)	218	53.83
ESD	0 (0%)	34 (47%)	32 (42%)	40 (61%)	32 (53%)	49 (60%)	187	46.17
Dwell								
0-1 day	12 (24%)	28 (39%)	20 (26%)	11 (17%)	11 (18%)	17 (21%)	99	24.4
2-4 days	33 (67%)	37 (51%)	43 (57%)	39 (59%)	29 (48%)	42 (51%)	233	55.1
5-8 days	4 (8%)	6 (8%)	13 (17%)	16 (24%)	14 (23%)	16 (20%)	69	17
9-25 days	0 (0%)	1 (1%)	0 (0%)	0 (0%)	6 (10%)	7 (9%)	14	3.5
Central IV	6 (16%)	5 (8%)	7 (11%)	7 (13%)	4 (8%)	5 (8%)	34	10.03
> 1 SPC Coexisting	10 (20%)	9 (12%)	11 (14%)	10 (15%)	9 (15%)	17 (21%)	66	16.3
Location								
Hand	5 (10%)	2 (3%)	13 (17%)	5 (8%)	6 (10%)	6 (7%)	37	9.14
Wrist	5 (10%)	8 (11%)	7 (9%)	4 (6%)	4 (7%)	9 (11%)	37	9.14
Forearm	16 (33%)	22 (31%)	29 (38%)	25 (38%)	17 (28%)	38 (46%)	147	36.3
Antecubital	17 (35%)	36 (50%)	23 (30%)	28 (42%)	25 (42%)	25 (30%)	154	38.02
Upper Arm	5 (10%)	4 (6%)	4 (5%)	3 (5%)	8 (13%)	4 (5%)	28	6.91
External Jugular	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1	0.25
Axillary	0 (0%)	0 (0%)	0 (0%)	1 (2%)	0 (0%)	0 (0%)	1	0.25
Gauge								
16	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (2%)	3	0.74
18	10 (20%)	9 (12%)	11 (14%)	7 (11%)	5 (8%)	15 (18%)	57	14.07
20	37 (76%)	62 (86%)	60 (79%)	54 (82%)	50 (83%)	62 (76%)	325	80.25
22	1 (2%)	1 (1%)	5 (7%)	5 (8%)	5 (8%)	3 (4%)	20	4.94
Site Signs and Symptoms								
WDL	41 (57%)	51 (67%)	27 (55%)	49 (74%)	35 (58%)	65 (79%)	268	66.17
Blood	30 (42%)	24 (32%)	21 (43%)	17 (26%)	24 (40%)	14 (17%)	130	32.1
Sign or Symptom	1 (1%)	1 (1%)	1 (2%)	0 (0%)	1 (2%)	3 (4%)	7	1.73
Removal Reason								
Per Policy	4 (8%)	10 (14%)	12 (16%)	4 (6%)	0 (0%)	5 (6%)	35	8.64
Site Symptoms	12 (24%)	10 (14%)	11 (14%)	8 (12%)	11 (18%)	11 (13%)	63	15.56
Per Patient	4 (8%)	2 (3%)	1 (1%)	3 (5%)	4 (7%)	3 (4%)	17	4.2
Per Order	0 (0%)	1 (1%)	1 (1%)	0 (0%)	0 (0%)	0 (0%)	2	0.49
Not Present	1 (2%)	1 (1%)	0 (0%)	0 (0%)	1 (2%)	3 (4%)	6	1.48
Not Indicated	16 (33%)	19 (26%)	18 (24%)	30 (45%)	22 (37%)	40 (49%)	145	35.8
No doc-At DC	12 (24%)	20 (28%)	29 (38%)	17 (26%)	20 (33%)	19 (23%)	117	28.89
No doc-Unknown	0 (0%)	9 (12%)	4 (5%)	4 (6%)	2 (3%)	1 (1%)	20	4.94
Failure	12 (24%)	10 (14%)	11 (14%)	8 (12%)	11 (18%)	11 (13%)	63	15.56

Note. Due to rounding, percentages may not equal 100%.

Appendix E

Table 2. *Summary Results for Number of SPCs, In Situ, Location, Gauge, and LOS*

Variable	*M*	*SD*	*n*	SE_M	Min	Max	Skewness	Kurtosis
SPCs per patient								
P1	2.90	2.11	39	0.34	1.00	9.00	1.46	1.57
P2	2.37	1.81	63	0.23	1.00	12.00	2.88	11.53
P3	2.37	1.76	65	0.22	1.00	10.00	1.92	4.53
P4	2.29	1.28	56	0.17	1.00	5.00	0.78	-0.41
P5	2.35	2.16	51	0.30	1.00	15.00	4.23	21.46
P6	2.22	1.32	65	0.16	1.00	7.00	1.34	2.00
Total	2.38	1.73	339	0.09	1.00	15.00	2.71	11.99
In Situ (days)								
P1	2.63	1.48	49	0.21	0.00	7.00	0.81	0.57
P2	2.25	1.77	72	0.21	0.00	10.00	1.55	3.99
P3	2.89	1.76	76	0.20	0.00	8.00	0.74	0.03
P4	3.17	1.78	66	0.22	0.00	8.00	0.64	-0.26
P5	3.85	2.92	60	0.38	0.00	13.00	1.35	1.62
P6	3.74	3.20	82	0.35	0.00	22.00	2.62	11.25
Total	3.11	2.35	405	0.12	0.00	22.00	2.30	11.23
SD	2.91	2.12	218	0.14	0.00	13.00	1.58	3.68
ESD	3.34	2.58	187	0.19	0.00	22.00	2.66	14.01
Hand	2.89	1.58	37	0.26	0.00	7.00	0.70	0.13
Wrist	2.46	2.29	37	0.38	0.00	9.00	1.60	1.85
Forearm	3.44	2.92	147	0.24	0.00	22.00	2.50	10.70
Antecubital	2.94	1.92	154	0.15	0.00	12.00	1.33	3.06
Upper Arm	3.29	1.86	28	0.35	0.00	8.00	0.66	0.15
16-G	3.33	0.58	3	0.33	3.00	4.00	0.71	-1.50
18-G	2.77	1.76	57	0.23	0.00	7.00	0.84	-0.09
20-G	3.13	2.43	325	0.13	0.00	22.00	2.46	12.11
22-G	3.70	2.64	20	0.59	0.00	9.00	0.60	-0.58
LOS (days)								
P1	4.69	2.82	39	0.45	0.00	12.00	0.75	-0.10
P2	4.32	2.94	63	0.37	1.00	14.00	1.33	1.46
P3	4.52	3.52	65	0.44	0.00	16.00	1.35	1.83
P4	4.79	3.39	56	0.45	0.00	17.00	1.33	2.04
P5	5.08	4.10	51	0.57	0.00	19.00	1.34	1.46
P6	5.25	6.34	65	0.79	1.00	47.00	4.85	28.05
Total	4.77	4.11	339	0.22	0.00	47.00	4.08	33.26

Appendix F

Figure 4. Bar Chart for Percentage of SPC Days In Situ by Phase