A Bundled Approach for Peripheral IV Site Care and Maintenance

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Abstract

Hospitalized patients receiving medications intravenously are at increased risk for developing hospital associated infections (HAIs), including MRSA if their peripheral intravenous catheters are not maintained appropriately. These HAIs pose a financial burden to both patients and institutions and increased morbidity and mortality for the patient. A bundled set of evidence-based interventions was implemented on three acute care units as part of a quality improvement project. The aim of the project was to ensure proper care and maintenance of intravenous catheter devices. Interventions included a) consistent use of a phlebitis infiltration scale; b) maintaining a clean, dry, and intact dressing with a securement device; and c) using a disinfecting cap on all catheter hubs and tubing. Nursing staff were educated using huddles, purposeful rounding, posters, videos, and reminder cards. Compliance with the bundled elements was measured using an audit tool during weekly point prevalence rounds. Post implementation data showed a 65% reduction in MRSA incidence rates. The compliance scores for all elements increased, on average, by 58% from 34.5% to 92.5%. The results suggest that the implementation of a bundled approach to the care and maintenance of PIVCs is clinically effective at reducing the incidence of MRSA bacteremia.

Keywords: Peripheral intravenous catheters, PIVC site care and maintenance, complications associated with peripheral intravenous catheters

A Bundled Approach for Peripheral IV Site Care and Maintenance

Hospital Acquired Infections (HAIs) continue to be a global burden, impacting patient safety and quality of care. In fact, the World Health Organization (WHO, 2016) estimates that in the United States of America, 1.7 million patients are affected by HAIs each year, and 99,000 of those affected die. Four types of infections widely recognized as preventable cause the greatest harm to patients: 1) catheter associated urinary tract infections (CAUTI), 2) surgical site infections (SSI), 3) ventilator associated pneumonia (VAP), and 4) catheter related bloodstream infections (CRBSI). The estimated economic burden to the U.S., according to the Centers for Disease Control and Prevention (CDC), is 35.7 to 45 billion dollars annually in direct care costs (WHO, 2016). In addition to the financial burden of treatment, HAIs also increase morbidity, mortality, and resistance to antimicrobials, which severely impacts the delivery of care.

The Hospital-Acquired Condition (HAC) Reduction program is a part of a Centers for Medicare and Medicaid Services (CMS) strategy to make patient care safer by imposing financial penalties on those institutions that rank the worst in a series of metrics. These metrics include hospital readmissions, healthcare associated infections (HAIs), and ten patient safety indicators that include items such as pressure ulcer rates and postoperative sepsis rates. CMS uses surveillance data for five measures, which are reported to the National Healthcare Safety Network (NHSN). The five measures include central line associated bloodstream infection (CLABSI), CAUTI, SSI, Methicillin-resistant *Staphylococcus aureus* (MRSA), and *Clostridium difficile* infection (CDI) for the HAI component (Centers for Medicare and Medicaid Services [CSM], 2018).

Background and Significance of the Problem

Most patients admitted to a hospital setting obtain peripheral intravenous catheters (PIVC) for their clinical treatment. These are the most common invasive intervention provided in the acute care setting, with over 200 million administered annually (Yagnik, Graves, & Thong, 2017). Substantial work has been performed to reduce the risk of CLABSI due to central venous access devices given the high risk that this device poses; however, any focus on primary BSI prevention in patients with only PIVCs has been limited. Austin, Sullivan, Whittier, Lowry, and Uhlemann (2016) stated that although the risk of bacteremia as a complication of PIVC is low, at an estimated 0.1% of patients with PIVC infections, its burden is substantial due to the large number of PIVCs inserted annually.

Similarly, Capdevila et al. (2016) suggested that the risk of bactermia in PIVCs is parallel to that of central venous access devices, with 0 to 5 occurences per 1,000 catheter days. Moreover, the organism most commonly identified in the PIVC setting is the bacteremia *Staphylococcus aureus*, which has associated mortality rates of up to 30% (Austin, Sullivan, Whittier, Lowry, & Uhlemann, 2016; Capdevila et al., 2016). In a surveillance study of 24,179 infections observed, Bernatchez (2014) reported that intravascular devices were the leading cause of bloodstream infections, accounting for greater than 10,000 PIVC-related *Staphylococcus aureus* bacteremia infections annually in the U.S. PIVC-related BSIs have been estimated to cost 35,000 to 56,000 U.S. dollars (Alexandrou et al., 2018). Compounding the problem are PIVC failure rates before the completion of treatment, estimated at 69% of all PIVCs placed, necessitating a PIVC replacement, which puts the patient at an additional risk of exposure (Ray-Barruel, Cooke, Mitchell, Chopra, & Rickard, 2018).

A myriad of elements can contribute to PIVC phlebitis, an inflammation of the vein that ultimately necessitates the need to remove the PIVC. Phlebitis can be mechanical, chemical, or infective in nature (Webster, McGrail, Marsh, Wallis, & Rickard, 2015). Mechanical phlebitis occurs when the PIVC is not secured properly or when the device is placed at a site with flexion. Catheter movement causes irritation to the vein intima, leading to pain, erythema, and edema. Chemical phlebitis occurs when the infusate or medication is irritating to the vein. Infective phlebitis can result from the improper disinfection of the patient's skin before line insertion, failure of the care provider to perform hand hygiene, and/or improper maintenance of the site after insertion, allowing bacteria to enter through the break in skin integrity. Insufficient decontamination of the catheter hub/access site before the instillation of fluids or medications is another potential source of infection. These complications lead to the failure of the device, which necessitates its removal and replacement if the therapy is not complete. The result is increased material costs, nursing workloads, treatment delays, lengths of stay, and additional risk to the patient of developing an infection. Finally, since the pain and anxiety associated with this procedure reduces patient satisfaction and potentiates an already difficult circumstance, the procedure must be considered.

Problem Statement/Purpose

The financial burdens, increased risk to the patient, and increased nursing workload associated with primary bloodstream infections necessitate the need to implement evidence-based strategies that target each of the complications inherent to the use of PIVCs. Hence, a bundled set of interventions addressing each of the elements that lead to PIVC failure is obligatory. From fiscal year 2017 to 2018, the identified healthcare organization doubled their Methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia infections. The risk of

morbidity and mortality associated with this type of infection coupled with the financial penalties incurred through the Hospital-Acquired Condition (HAC) Reduction program for MRSA bacteremia make this an important clinical issue requiring resolution (Centers for Medicare and Medicaid Services, 2018). The purpose of this QI project was to implement a bundled care and maintenance program for PIVCs. The specific aims were to reduce the incidence of MRSA bacteremia, increase dwell time, decrease IV cannula usage, and decrease IV start kit usage by utilizing a bundled care and maintenance protocol for PIVCs in the inpatient acute care setting. The practice environment did not evidence an established standardized care and maintenance protocol. Therefore, an integrative literature review was conducted to identify an evidenced based approach to PIVCs care and maintenance.

Literature Review

Search Strategy

The Cumulative Index to Nursing and Allied Health Literature database (CINAHL), EBSCOhost, Google Scholar, PubMed, Ovid, and ProQuest Nursing & Allied Health Source databases were systematically searched from January 2013 through September 2018. Combinations of keywords included in the literature search were *peripheral intravenous catheters*, *care and maintenance*, *bloodstream infections*, *intravascular catheter related infections*, and *complications associated with venous access devices*. Additional studies were identified manually via reference lists from previously identified articles; however, these studies were not included as they were more than ten years old.

The search yielded over forty-five articles, of which ten were originally selected to ascertain themes and trends for the care and maintenance of peripheral intravenous catheters.

The search was limited to full text, English language, and peer reviewed articles. Four of the articles originated in the U.S., three in Australia, and one each from the Netherlands, Sweden, and Spain. The Johns Hopkins Research Evidence Appraisal Tool was used to assess the level of evidence provided in each of the studies selected (Dearholt & Deborah, 2012). The ten quantitative studies selected had evidence levels ranging from one to two. One systematic review of randomized controlled trials (RCTs; Marsh, Webster, Mihala, & Rickard, 2015) was rated as an evidence level one study and one systematic review and meta-analysis that did not contain RCTs (Moureau & Flynn, 2015) rated as an evidence level 2 study. One systematic review and meta-analysis included a mix of RCTs (Voor et al., 2017), and there were seven quasi-experimental studies (deRosenroll, 2017; DeVries, Mancos, & Valentine, 2014; Duncan, Warden, Bernatchez, & Morse, 2018; Goransson, Forberg, Johansson, & Unbeck, 2017; Rhodes et al., 2016; Rickard et al., 2018; Yagnik, Graves, & Thong, 2017).

Review of Relevant Literature

Although several strategies for the successful maintenance of PIVCs are explored in the literature, four were identified in the literature review as the most successful for preventing PIVC failure and infection. The interventions included sterilizing dressings and securement devices, disinfection of the access port, assessment of the IV site, and the use of a bundled set of these interventions. Many of the interventions discussed in the research relate to the care and maintenance of central lines. However, the practice improvements implemented to reduce CLABSI should be evaluated to ensure a standardized clinical practice in the care and maintenance of PIVCs as well, especially in light of data showing that nosocomial bacteremia, especially *Staphylococcus aureus*, is associated with the use of this device (Austin, Sullivan,

Whittier, Lowry, & Uhlemann, 2016; Brady, Bruno, Marchionni, & Paquet, 2016; Capdevila et al., 2016).

Dressings and securement devices to prevent PIVC failure. PIVC dressings are used as a barrier to infection. Securement devices help to prevent the migration of the catheter in and out of the vein, which can also lead to infection and mechanical phlebitis. In a study conducted by deRosenroll (2017), the use of a closed PIVC system with a securement dressing was implemented to determine its effect on incidence of peripheral IV complications. Data were collected at three different intervals—pre-implementation, post implementation (6 months), and post-implementation (18 months)—with 431 observations made. Phlebitis rates at a baseline of 29% were reduced by 10% at six months and by 21% at 18 months. Other significant results included a 45% reduction in dislodgemment, a 36% reduction in leaking at the site, and a 42% reduction in the need for PIVC replacement due to kinking.

Marsh, Webster, Mihala, and Rickard (2015) appraised six randomized controlled trials (RCTs) that evaluated four different products that help to keep PIVCs in place and prevent infection: a plain transparent film dressing compared with gauze, a bordered transparent dressing compared with non-sterile medical tape, a plain transparent film dressing compared with sticking plaster, and a bordered transparent dressing compared with a securement device used with a transparent film dressing. Outcome measurements included PIVC failures due to IV complications, phlebitis, infiltration, and dislodgement. Three of the trials included in the systematic review compared transparent dressings with gauze dressings. The only significant finding when results were combinded using a fixed effect model was that the transparent dressings (7/136) had significantly fewer incidences of dislodgement than gauze (19/142). One trial evaluated the use of a bordered transparent dressing with a securement device. Its only

significant finding was that the bordered transparent dressing group had fewer incidences of dislodgement than the securement group. When a bordered transparent dressing was compared to tape in another trial, the tape group reported fewer PIVC failures than the bordered transparent dressing group. Finally, another trial compared transparent dressings with sticking plaster. There were no distinctions in any of the outcomes measurements between these two groups. Using the GRADE approach, an established method used to rate the quality of evidence for the studies in systematic reviews, the authors reported a very low quality of evidence for each of the trials. Thus, no substantial conclusions can be drawn on the best type of product to secure and dress PIVCs from this analysis.

In a study by Rickard et al. (2018), patients were randomly assigned four different dressing and securement methods: a simple polyurethane dressing, tissue adhesive combined with polyurethane dressing (control), a bordered polyurethane dressing, and a polyurethane dressing with a securement device. A group of 1,697 participants at two hospitals in Queensland, Australia were included. The data analysis included calculating the relative incidence of PIVC failure between each group using Fisher's exact test. Additionally, PIVC failure rates per 100 days were calculated, including incidence rate ratios and 95% confidence intervals (CI), to discover the efficacy of each of the methods compared to the control. The absloute risk between the control method and the three trialed method revealed less than a 10% difference, indicating no significance. Moreover, no statistically significant differences between the four groups as related to PIVC failure (p=0.21 to p=0.74) were discovered.

There is a paucity of high quality evidence and research regarding the methods used to dress and secure PIVCs. The number of methods and materials available makes selecting the right combination to prevent PIVC failure a daunting task. However, it is well documented that

proper occlusive dressing and securement prevent the infection and phlebitis that lead to PIVC failure (deRosenroll, 2017; Marsh, Webster, Mihala, & Rickard, 2015; Rickard et al., 2018). In their Infusion Therapy Standards of Practice (2016), the clinical experts at the Infusion Nurses Society (INS) have also discussed the importance of dressing integrity and securement to prevent PIVC failure and infection (Infusion Nurses Society, 2016).

Disinfection of needle free devices (catheter hubs). Needle-free devices (NFD) were implemented in the U.S. in 1992 to prevent injuries secondary to needle sticks. Although NFDs promote safety from needle stick injuries for both patients and care providers, they can cause harm if not used properly. If they are not cleansed thoroughly before application, bacteria from the patient's own skin and the environment can be injected into the patient's bloodstream, causing intraluminal contamination (DeVries, Mancos, & Valentine, 2014; Moureau & Flynn, 2015; Voor et al., 2017). The INS recommends a vigorous mechanical scrub, before each access of a vascular device, with 70% isopropyl alcohol, iodophors, or 0.5% or greater chlorhexidine in an alcohol solution for the length of time appropriate to the NFD and the properties of the disinfecting agent (Infusion Nurses Society, 2016). Variations in time, product, and device make the use of a disinfecting cap a viable infection control practice (DeVries, Mancos, & Valentine, 2014; Moureau & Flynn, 2015; Voor et al., 2017).

DeVries, Mancos, and Valentine (2014) performed a prospective observational study in two acute care hospitals to determine whether the use of a disinfection cap reduced primary BSI in patients with central lines, peripheral IVs, or both. Failure to manual disinfect catheter hubs and other internal data suggested that 21% of the institutions' BSI infections were associated with patients with only PIVC, while 47% of BSI infections resulted from both a central line and a peripheral IV prompting the intervention. BSI rates for patients with only PIVC decreased by

49.3% post intervention (0.075/100 patient days to 0.038/100 patient days). The combined BSI rate decreased by 50% from 0.086/100 patient days pre-intervention to 0.043/100 patient days post intervention.

To ascertain the best practices for disinfecting NFDs, Moureau and Flynn (2015) conducted a systematic review of sixty-seven articles discussing both manual and passive disinfection methods and types of disinfectants. The disinfectants reviewed—70% isopropyl alcohol, 10% povidone iodine, 10% sodium hypochlorite, and 2% chlorhexidine—all showed efficacy in removing bacteria from the surface of the NFD at varying lengths of time, from five second to 60 second scrubs. However, multiple studies in the review showed that 2% chlorhexidine in 70% isopropyl alcohol was superior to the other agents, providing surface protection for up to 24 hours. Variability in the amount of time needed to disinfect the NFD manually was cited as a barrier to compliance with proper disinfection practices. Of the sixty-seven articles reviewed, twenty-three focused on passive disinfection through the use of a cap with 70% isopropyl alcohol. In each of the studies discussed, CLABSI rates significantly decreased with the implementation of the disinfecting cap, with reductions as high as 61%.

Similarly, Voor et al. (2017) conducted a systematic review and meta analysis of the literature to compare the effectiveness of using an antiseptic barrier cap compared to manual disinfection in preventing CLABSIs. Nine prospective quasi-experimental before and after studies were identified for the systematic review; out of those, seven were selected for the meta-analysis. The methodological quality of the studies was rated at 13 on a scale from 7 to 5, and they were deemed as moderate in their quality of evidence. Applying a pooled incidence rate ratio (IRR=0.59, 95% CI 0.45-0.77, $I^2 = 27\%, P < 0.001$), the use of an antiseptic barrier was shown to be effective in reducing rates of CLABSI. Antiseptic barrier cap use proved to have an

82.5% median rate of compliance, which was considerably higher than the rate of compliance with manual disinfection. Passive disinfection with an antiseptic infused cap has been shown in several studies to increase compliance with the disinfection of NFD and reduce incidence of bloodstream infections (DeVries, Mancos, & Valentine, 2014; Moureau & Flynn, 2015; Voor et al., 2017).

Assessment of PIVC insertion site. The INS best practice recommendations for reducing CRBSIs and increasing patient satisfaction require a daily assessment of any vascular access device to detect phlebitis and/or infiltration (Infusion Nurses Society, 2016). Yagnik, Graves, and Thong (2017) completed a prospective study of adherence to PIVC documentation and monitoring guidelines before and after the implementation of three interventions. The interventions consisted of a Plastics in Patients (PIP) Poster, a PIP Strip, and a PIP Row. The PIP poster was attached to each insertion supply cart as a visual reminder for staff to remove unnecessary PIVCs, use proper insertion techniques, and document the procedure properly. The PIP strip, another visual cue, identified all patients on the unit with a PIVC (as recorded on the unit's patient board) and discussed among multidiscplinary team members daily. The PIP row was a prompt in the medical record for physicians to review PIVC indication. Postintervention, Documentation of the date of insertion improved from 36.4% to 50% (P=0.25). PIVCs were discontinued earlier postintervention (26.1%) compared to preintervention (14.3%). Early identification of phlebitis/infiltration and timely removal were both associated with BSI prevention (Ray-Barruel, Polit, Murfield, & Rickard, 2014).

Evaluating phlebitis using a consistent, standard, and feasible method is an Infusion Nurses Society (2016) standard of practice. Goransson, Forberg, Johansson, and Unbeck (2017) executed a cross-sectional study to demonstrate variations among the different instruments used

for assessing PIVCs. In their study, seventeen evaluated instruments fell into three categories: instruments using definitions (8), instruments using severity rating systems (7), and instruments using scoring systems (2). The researchers applied each of the instruments at a total of 1,175 site assessments. They discovered, based on the documentation elements provided, that the variation phlebitis percentage within the same instrument ranged from 1% to 28%, indicating a lack of confidence in successful phlebitis identification. Moreover, severity rating systems were more likely to have the highest amounts of PIVC phlebitis scored (395/1175, 34%) compared to the instruments using definitions (137/1175, 11.7%). Variabily in the application of the different scales used to assess phlebitis indicated a need for validation of the scales. The two phlebitis scales endorsed by the INS are the Phlebitis Scale and the Visual Infusion Phlebitis Scale, both of which have demonstrated content validity and interrater reliability (Infusion Nurses Society, 2016).

Bundled approach. The Institute for Healthcare Improvement (IHI) defined a bundle as a small set of evidenced-based interventions used for a defined population that, when executed collectively, result in significantly better outcomes than when implemented in isolation (Resar, Griffin, Haraden, & Nolan, 2012). A substantial body of literature supports the use of a multi-modal bundled approach to the prevention of infections associated with central lines, but only a limited amount of evidence supports its use in the care and maintenance of PIVC to prevent failure and infection.

Duncan, Warden, Bernatchez, and Morse (2018) developed a peripheral line associated bloodstream (PLABSI) prevention bundle using guidelines from the CDC, INS, and the Society for Healthcare Epidemiology of America (SHEA). The bundle included an assessment of the site for phlebitis, examining the dressing, using alcohol-impreganated disinfection caps, and

minimizing all disconnections of the primary tubing if possible. After establishing a baseline and providing education, 2,355 lines were audited for compliance with the bundled elements. Post-intervention, a reduction compared to pre-intervention values in BSI attributed to PIVC was noted (0.57 to 0.11 infections per patient days; $p< 0.0001$). MRSA was identified in four of the thirty-nine PIVC-related bloodstream infections pre-intervention and none of the eight identified bloodstream infections post-intervention.

Rhodes et al. (2016) implemented a care bundle in an effort to reduce healthcare-associated *Staphylococcus aureus* bacteremia (HA-SAB) at their 860 bed hospital in Australia. Their bundle, informed by a literature review of evidenced-based pratices, consisted of dressing and labeling the PIVC, documentation, and noting the presence of phlebitis. A newly developed observation chart and a revised scoring system were implemented, along with improved documentation. Audits were performed on patients pre-intervention (273) and post-intervention (279). Phlebitis scoring increased post-intervention, with scores of 0 most often identified (92.1% to 77.6%; $P< 0.05$). Improved documentation was also noted. Pre-intervention, 68 (35%) of HA-SAB were attributed to PIVCs, equaling a rate of 0.39 per 10,000 occupied bed days (OBD). Post-intervention, 12/83 (14.4%) of the HA-SAB were associated with PIVC, correlating to a 63% reduction (relative rate: 0.36; 95% *CI* 0.17,0.76; $P= 0.018$). Both studies indicated that the adoption of multiple interventions can decrease incidences of bloodstream bacteremia.

Appraisal of Studies

In this review of the literature, four basic nursing interventions were evaluated for PIVC care and maintenance: (1) dressing and securement, (2) disinfection of access sites, (3) assessment of the PIVC site, and (4) a bundled approach using multiple interventions. Due to the

many variables involved in the research designs of these studies, their quality of evidence was rated as a good or low based on the Johns Hopkins tool for grading evidence and quality (Goossens & Hadaway, 2014). However, the interventions are widely supported for central venous access care and could be extrapolated for the care and maintenance of PIVCs.

Dressings and securement devices to prevent PIVC failure. The practice of securing intravenous lines so that they do not cause irritation as they migrate in and out of a vessel, leading to eventual dislodgement and the need for replacement and maintaining the integrity of that dressing or securement device, is well supported throughout the literature (de Rosenroll, 2017; Goossens & Hadaway, 2014; Marsh, Webster, Mihala, & Rickard, 2015; Rickard et al., 2018). Three studies have been conducted to determine what effect, if any, the type of dressing or securement device has on the maintenance of PIVCs: a level one systematic review of the literature, a level two quasi experimental observational study, and a level two randomized and controlled superiority trial (deRosenroll, 2017; Marsh, Webster, Mihala, & Rickard, 2015; Rickard et al., 2018).

de Rosenroll (2017) used a "seek, solve, and sustain" model to evaluate the implementation of a closed system PIV catheter with a built-in stabilization platform. Multiple variables were assessed, including the rate of catheters that needed to be replaced, compliance with the new device, the rate of catheter complications, and consistency with practice. The design of the study was strong, as trained infusion nurses made the observations on 431 catheters over two days. Although rates of restarts decreased by 45% and phlebitis decreased by 17%, a *p* value for statistical significance was not reported.

Marsh, Webster, Mihala, and Rickard (2015) conducted a comprehensive review of the literature to examine the influence of PIVC dressings and securement devices on incidence of PIVC failure. The researchers searched several databases, including the Cochrane Register of Controlled Trials, the Cochrane Wounds Group Register, EBSCO CINAHL, Ovid MEDLINE, and Ovid EMBASE. Six RCTs with trial sizes ranging from 50 to 703 members were reviewed. Randomized controlled trials that compared dressing or securement devices made from any type of product were included. Unfortunately, this scope omitted a wide range of products that are available, limiting the generalizability of the study. The authors cited several constraints in their systematic review, including the inadequate number of studies available for review, the lack of reviews of all dressings and securement devices available on the market, and a lack of high quality in the initial studies' research methodologies, designs, and data collection. Thus, a conclusive determination of which dressings and securement devices are most effective could not be drawn from the studies reviewed.

Finally, Rickard et al. (2018) conducted a superiority trial comparing four types of dressing and securement devices and ran several statistical tests to analyze the results. They used a Kaplan-Meier analysis to discover the probality of PIVC failure over time. None of the dressing types were statistically different. They also employed mutlivariate analysis to compare multiple demograhic variables amongst the four groups. Again, no appreciable differences were found, and all *p* values were reported. Although a best type of dressing and/or securement device could not be vetted from the review of these three articles, ensuring a clean, dry, and intact dressing that prevents the catheter from moving within the vessel was established as an intervention that could be adopted for a peripheral line associated bloodstream infection

prevention bundle (deRosenroll, 2017; Marsh, Webster, Mihala, & Rickard, 2015; Rickard et al., 2018).

Disinfection of needle free devices (catheter hubs). The healthcare environment poses many risks to the hospitalized patient. One such risk is the bacterium that lives in the environment, on the patient's own skin, and on healthcare workers' hands (CDC, 2018). MRSA can migrate and access the bloodstream through any break in the skin's integrity, including a PIVC. Removing the bacteria before accessing intravascular devices and pushing the bacteria into the intraluminal space are essential to preventing bloodstream infections. Two level two quasi-experimental studies and one level two systematic review were examined to review the effectiveness of using an antibacterial cap to prevent bacterial contamination on PIVC access ports (DeVries, Mancos, & Valentine, 2014; Moureau & Flynn, 2015; Voor et al., 2017).

DeVries, Mancos, and Valentine (2014) created a multimodal approach to the adoption of a disinfection cap in their hospital systems. First, they allowed the end user to select the disinfecting cap. This is a critical step in the adoption of changes in a current process. The intensive care nurses selected the preferred disinfecting cap because it twisted on easily, its orange color made it easy to assess compliance, and continual bathing of the port in disinfectant eliminated the need to scrub the hub. After successful adoption in the ICU, the use of the disinfecting cap expanded to all access sites across all units. Run charts were used to show BSI rates pre and post intervention. Statistical significance in reducing BSI rates in patients with central lines was shown pre and post intervention ($P<.00037$). Although there was not a statistically significant difference in BSI rates pre and post intervention for those patients with only a peripheral line ($P =.078$), the authors noted that this was the only change made for the

care and maintenance of PIVC during the timeframe of their study. Thus, the entirety of the progress made could be attributed to the adoption of this device.

Moureau and Flynn (2015) conducted a systematic literature search of PubMed, Medline, Scopus, Ovid, jStor, CINAHL, Cochrane, and Science Direct from 1977 to 2014 and found no randomized controlled trials that showed a causal relationship between the disinfection of access ports and infection; thus, they reviwed clinical and in vitro studies only if the study contained quantitative data. Based on their review of sixty-seven such articles, the authors presented a table of eight reccommended practices based on their level of evidence and derived from the National Health and Medical Research Council (NHMRC) defintions (National Health and Medical Research Council, 2009). The NHMRC body of evidence matrix grades each study based on evidence base, consistency, clinical impact, generalizability, and applicability with grade A being excellent and grade D being poor (National Health and Medical Research Council, 2009). Their recommendations included disinfecting the surfaces of NFD and other intravascular access ports before any connection (Grade B), using antimicrobial caps for continuous hub disinfection (Grade B), ensuring compliance with hand hygiene before any contact with an intravascular device (Grade B), educating all clinical staff on the standardized protocol to disinfect catheter hubs before and after each access (Grade B), providing consistent and varied education on consequences of poor technique (Grade C), establishing regular surveillance of compliance for disinfection with the reporting of information to units (Grade C), establishing a formal process to evaluate new technology (Grade A), and implementing a multimodal quality improvement that utilizes guidelines for all intravascular devices (Grade B).

In a systematic review and meta analysis, Voor et al. (2017) conducted a comprehensive literature search of Embase, Medline Ovid, Web of Science, CINAHL, EBSCO, Cochrane

Library, PubMed, and Google Scholar to compare manual disinfection with a passive disinfection cap. Of the nine studies reviewed in this meta analysis, only one included PIVCs. The primary measurement outcome was the rate of bloodstream infections, measured as an incidence rate ratio (IRR). The value of the studies varied significantly (IRR 0.14 to 0.76), but this could be attributed to the heterogenity of the study sites, which included oncology units, ICUs, and medical units in two different countries. The methodological quality of the studies reviewed included only three of high quality. Nonetheless, the authors concluded that the use of an antiseptic barrier cap does result in a risk reduction, compared to manual disinfection, in incidence of bloodstream infections.

Assessment of PIVC insertion site. Three level two quasi-experimental studies were reviewed in this category (Goransson, Forberg, Johansson, & Unbeck, 2017; Yagnik, Graves, & Thong, 2017). Yagnik, Graves, and Thong (2017) demonstrated that the use of visual cues to prompt staff to assess PIV sites resulted in fewer PIVC-related complications. One of the main objectives of this prospective run-in audit was to create interventions that were cost neutral. By creating three visual cues, they were able to focus the assessment of PIVCs without additional cost. The complication rate pre-intervention was six compared to zero (p=.08) post-intervention, indicating better assessment of early phlebitis. The authors did note that the study was too underpowered to accurately demonstrate the exact number of episodes of phlebitis reduced using these interventions.

Goransson, Forberg, Johansson, and Unbeck (2017) evaluated the use of seventeen different instruments to assess for and identify phlebitis. They demonstrated that there were discrepancies between the various tools in the level of phlebitis observed. Interrater relaibilty amongst the observers was k=0.81 (range 0.78-1.00), which demonstrated that the observers

agreed on almost all assessments using the tools. The authors noted that the reliability and validity of the tools themselves have not been vetted enough to endorse one with confidence. In addition, not all instruments used to assess phlebitis were studied and there are newer instruments available. Consistent assessment and early identification of phlebitis reduces PIVC complications and infections, but it has not been adopted a singular tool (Goransson, Forberg, Johansson, & Unbeck, 2017; Yagnik, Graves, & Thong, 2017).

Bundled approach. Bundled approaches to the care and maintenance of central lines have been embraced, with a successful reduction in CLABSI rates worldwide (CDC, 2018). Two level two quasi-experimental studies have explored the adoption of a bundled approach to the prevention of PIVC-related complications (Duncan, Warden, Bernatchez, & Morse, 2018; Rhodes et al., 2016). Duncan, Warden, Bernatchez, and Morse (2018) implemented a bundle consisting of the application of disinfecting caps on access ports and disconnected line ends, consistent assessment of PIV site, and the early removal of PIV if phlebitis is suspected. The authors used the standardized NHSN definition to determine BSI. In the post-intervention period, an 81% ($p < 0.0001$) reduction compared to the pre-intervention period was noted in PIVC associated BSI. An important limitation of this study was that it was performed in a single institution over a short timeframe. It would be important to see if the same results could be replicated, and sustained, in other settings.

Rhodes et al. (2016) implemented multiple interventions to determine the impact on HA-SAB infections in the setting of PIVC. Their interventions included a poster campaign to raise awareness of infection risks, staff education on the removal of PIVCs at 72 hours, the implementation of a new four-tiered phlebitis scoring system, and improved access to all necessary equipment by implementing a cart on every unit carrying the necessary supplies. HA-

SAB was determined using the national standard defintion in Australia. The HA-SAB infections attributable to PIVC decreased by 63% from pre-intervention to post-intervention (relative rate: 0.36; 95% confidence interval [CI]: 0.17, 0.76; p= 0.018). The institution has maintained this reduction for over 2 years post-implementation. Bundled that include a standardized assessment tool for phlebitis measurement, the use of disinfecting caps, and the early removal of PIVCs has been successful in limited single institution studies (Duncan, Warden, Bernatchez, & Morse, 2018; Rhodes et al., 2016).

Although each of the three interventions explored demonstrated positive results, the most significant results were apparent when multiple interventions were bundled to address each of the elements that can lead to PIVC failure. Thus, a secure dressing that reduces mechanical phelbitis, a consistent measurement tool for evaluating phlebitis, and the use of disinfecting caps to reduce infective phelbitis were joined to create a bundled intervention. Similar to the work seen in central line associated bloodstream infections, the best infection reduction results have been garnered through the use of multiple combined interventions.

Theoretical and Quality Improvement (QI) Framework

QI is the cornerstone of improving patient care delivery. The Model for Improvement (MFI) developed by the Associates in Process Improvement combines an initial inquiry into the aim, measures, and changes needed for implementing a process improvement, coupled with a rapid cycle Plan Do Study Act (PDSA) improvement process (Institute for Healthcare Improvement, 2019). The MFI was used to guide the development and implementation of this QI project (see Appendix A). The initial steps in the MFI process are to establish what is to be accomplished, how to know when a change is an improvement, and what changes can be made

that will result in improvement. This part of the framework was used to understand the specific problem and guide the pre-assessment audit. The PDSA cycle was used to analyze the initial audit data and select a process improvement plan. Implementation of the bundled interventions to improve PIVC site care and maintenance helped to determine if the action taken met the need of the organization. Ongoing assessment was necessary to determine continued efficacy and whether additional PDSA cycles are needed for ongoing improvement.

Christine Covell developed the theory of nursing intellectual capital (NIC; 2008) to establish how the interrelationships between nursing work environments, nursing knowledge, nursing experience, and nursing skills learned through continuing professional development (CPD) correlate with patient and organizational outcomes. Covell's middle range theory was derived from intellectual capital theory, which was developed primarily in the work of Karl Erik Sveiby and Leif Edvinson (Covell & Sidani, 2013). Intellectual capital theory had its origins in the business world, especially economics and accounting. Sveiby and Edvinson, among others, postulated that knowledge and other intangibles like education, experience, skills, and values are instrumental to the success of the organization and, thus, are financial assets (Viedma, 2007). Covell carried this concept into the field of nursing by theorizing that the sources of nursing knowledge available within an organization have a defined relationship with the success of the organization. That theory serves to guide research on quality work environments as well as to assist with administrative decision-making related to nursing resource management and continuing professional development (Covell & Sidani, 2013).

Intellectual capital (IC) has been defined as the combination of the collective knowledge of individuals and structures in an organization or societies deemed critical to an organization's continued success (Viedma, 2007). There are three primary components of IC: human capital,

structural capital, and social or relational capital (see Appendix B). Translated into the profession of nursing, human capital represents the knowledge, skills, and experience of the registered nurse (RN) while structural capital refers to the nursing knowledge that is converted into materials like clinical practice guidelines that support the use of nursing human capital within an organization (Covell, 2008). To assess and manage patients in hospital settings correctly, a complex combination of clinical experience, past and on-going education, evidence-based guidelines, and hospital policy must be fused to create the capital needed for quality outcomes. Covell's (2018) theory will be used as a framework for the development and implementation of this project, with an emphasis on the importance of using evidence-based interventions to support continued nursing knowledge.

Project Description/Design

Based on the evaluations of current evidenced-based practices noted in the literature to date, a bundled set of interventions was created to develop a comprehensive peripheral intravenous catheter (PIVC) site care and maintenance program. The PIVC site care and maintenance evidence-based bundle included (a) consistent use of a phlebitis infiltration scale, (b) maintaining a clean, dry, and intact dressing with a securement device, and (c) using a disinfecting cap on all catheter hubs and tubing. Additionally, the PIVC bundle included an introduction of a new IV start kit which included a dressing with a catheter securement system to prevent multi-directional tugging and dislodgement. The development of this pre/post intervention QI project included consultation with key stakeholders, PIVC assessment and chart audits, and BSI surveillance data. The DNP Project Lead conducted twice weekly audits both visually of the insertion site and of the documented elements in the electronic medical record. To ensure no bias was introduced, the DNP Project Lead was the only auditor on the visual

observations of the PIVC site. This QI project was supported by the Chief Quality Officer, Chief Nursing Officer, and System Director of Clinical Practice at the institutional site. The intervention took place on three units, including a progressive care unit, a medical/surgical unit, and an intensive care unit in a 450-bed tertiary not-for-profit hospital in Northern Florida. All patients admitted to these units with an existing PIVC during the established timeframe were subject to inclusion in the intervention and audit.

Ethical Considerations

This QI project received approval from the Jacksonville University (JU) BRCHS DNP Project Review Committee and the clinical organization's internal approval bodies. The QI project was submitted to and approved by both the JU Institutional Review Board (IRB) and the organization's IRB. This QI project is exempt according to both IRBs because all the data collected was de-identified and no risk to participants or the organization was expected. Since no patient identifiers were collected, no consent for inclusion was necessary.

Data security and storage. All project data were stored on the clinical facility's encrypted and password protected server. The NHSN benchmark data were maintained in the CDC cloud-based system used by the clinical facility. MRSA data were maintained in the HIPAA compliant facilities infection control system. All paper documents were stored in a locked cabinet in the DNP student's locked office at the clinical facility. All data sharing for analysis was conducted via a shared JU OneDrive, a cloud-based and password protected folder developed by the faculty chair. The faculty chair maintained the de-identified data in this folder per JU IRB guidelines. Any paper forms used at JU were stored in a locked file cabinet in the

faculty chair's JU office. The forms were scanned electronically and stored in the project's OneDrive folder. The paper documents were shredded per JU policy.

Project Goals and Objectives

The primary aim of this QI project was to evaluate the effectiveness of a multimodal evidence-based intervention program for reducing MRSA bacteremia associated with PIVCs. The first goal for the implementation of a PIVC care and maintenance bundle was to eliminate MRSA bacteremia rates for the identified units during the project period. The second goal was to increase the knowledge of the staff as it relates to the care and maintenance of PIVCs. Lastly, the third goal was to demonstrate a financial benefit to the organization through the implementation of this QI project.

The first goal, the elimination of MRSA infections attributed to PIVCs, was thought to be achieved by virtue of decreasing the risk of phlebitis. The successful adoption of all the elements of the identified care and maintenance bundle, namely, the consistent use of a phlebitis scale, decreased mechanical phlebitis through the adoption of a dressing with securement device, and the use of a disinfecting catheter hub—was the critical objective. Compliance with the bundled elements was measured using the audit tool created by the author during weekly point prevalence rounds (Appendix C). There were 1,039 admissions during a three-month period for the identified units; thus, to meet a 95% Confidence Interval with a 5% margin of error, 278 PIVCs were audited (see Appendix D). The expected compliance with all the elements identified in the bundle was 90%.

The secondary goal of the QI project was to increase staff knowledge of the causes of PIVC phlebitis failure and the need for replacement, infiltration, a phlebitis scale, and a hospital

policy regarding PIVC care and maintenance. This goal was addressed through two primary objectives. The first objective was to provide in-service training for team members on the in-patient units during monthly staff meetings and changes of shift huddles with the objective of reaching 90% of the 122 team members on the identified units. The second objective was to increase team members' fundamental knowledge of peripheral IV site care and maintenance principles, including how to assess phlebitis/infiltration using a standardized scale and understanding the causes of phlebitis. Team members were expected to have an 85% pass rate on a post-test. Their knowledge levels were assessed by comparing pre- and post-test scores from a twelve-question tool assigned to all team members through the institution's Cornerstone application. Additional one-on-one education and post-test review was provided to those team members who did not achieve an 85% on the posttest assessment to ensure their competency and foundational knowledge.

The final goal of this QI project was to establish a financial benefit to the organization through the implementation of this QI project. Through the stabilization of PIVCs, catheters can remain in situ longer, which decreases the need for repeated IV insertions that increase the risk of infection. Correspondingly, increased dwell times will lead to the decreased use of IV cannulas and IV start kits and to a decrease in the nursing time and resources needed to replace PIVCs. The objectives of this goal were to increase dwell times by 20% and decrease IV cannula and IV start kit usage by 10%.

Intervention and Implementation

The QI project was implemented in three phases (see Appendix E). Baseline observations included an audit of current clinical practices via a data collection tool developed to

assess compliance with existing facility policy. Consultation with key stakeholders, including the Chief Quality Officer, Chief Nursing Officer, Infection Prevention, Nurse Managers, and Vascular Access team members, was conducted to determine the present barriers to PIVC care and maintenance. Before this education, during the three months of the project timeline, a pre-test was assigned to all team members; the pre-test utilized the Cornerstone application to assess current knowledge levels and identify knowledge gaps (see Appendix F). Reducing MRSA infections across the health system has been identified as a key strategic initiative for FY2019. The average dwell time per unit, the number of IV cannulas per unit, and the number of IV start kits per unit were also recorded during the baseline period.

In month four of the implementation period, during monthly staff meetings and change of shift huddles the DNP Project Lead held education sessions for team members regarding the elements of PIVC care and the maintenance bundle. The education included the use of the phlebitis/infiltration scale and the application of a new dressing. Educational materials including posters, videos, and reminder cards were provided. The DNP also conducted weekly rounding on units to determine the acceptability of the identified interventions and any barriers to their adoption. After this education process was provided, the new IV start kits were delivered to the three project units for use.

After the new kits were in use on the assigned units for 1 month (at month five of the project), compliance with the bundled elements was conducted using a paper audit tool developed by the author (Appendix C). Also, at month five, the test utilized during the implementation phase was assigned to all team members once again to determine knowledge gained during the course of the QI project rollout. Weekly rounding on units ensured staff adoption of the protocol and helped to remove any identified barriers. The average dwell time

per unit, the number of IV cannulas per unit, and the number of IV start kits per unit were recorded throughout the evaluation period. MRSA rates continued to be tracked.

Financial Costs

The IV start kit used cost $0.99/ea. with an annual usage in FY2018 of 252,790. The new IV start kit will cost $2.12/ea., which will result in an annual increase in cost of $285,652.70. However, additional polyurethane dressings needed to replace loosened dressings and the use of separate IV securing devices are eliminated. The cost for both of these products for FY2018 was $102,440. Thus, the adjusted expense for the transition to a new IV start kit will be $183,212.70 annually, which does not include the expected decrease in IV start kit usage secondary to extended dwell times. The cost of educational materials, which included the printing of 10 posters, was $250. The direct medical cost to treat MRSA ranged from $27,083 to $34,900 per case (Klein et al., 2019). In FY2018, the organization had seven MRSA infections, which would cost, at minimum, $189,581. Additionally, the mortality rate for patients with MRSA is double that of those who contract non-resistant strains of bacteria, further increasing hospital costs. Although the price of the supplies increased, the reduction in infections, IV cannula usage, and IV start kit usage offset the cost difference.

Sustainability

The incremental increase in MRSA infections across the institution over the last 2 years has brought about an increased awareness among hospital senior leadership of the risks associated with PIVC site care and maintenance. As such, finding strategies to reduce MRSA infections is a key initiative for the health system. Audits will continue on inpatient units until compliance with bundled elements reaches greater than 90% and MRSA rates are better than the

25th percentile nationally (Appendix C). The results of the audits will be displayed in run charts for MRSA bacteremia across the facility and in individual units. Internal benchmarking for bundle compliance rates will be displayed on unit dashboards. The evidence-based bundled interventions will be sustained and spread to other departments as part of the clinical facility's strategic plan for quality and patient safety.

Evaluation Plan

Summary tables (descriptive statistics and/or frequency tables) were provided by intervention period (pre versus post) and time (Months 1, 2, and 3) for all key variables, including PIV care and maintenance, MRSA rates, and test score data. Continuous variables were summarized with descriptive statistics (*n*, mean, standard deviation [*SD*], median, minimum and maximum). The frequency count and percentage of subjects within each category are provided as categorical data. The test score was calculated as the percentage of correct answers before and after the educational sessions. A summary of each element of PIV care and maintenance bundle (i.e., dressing clean, dry, and intact; daily bath and linen changes; whether the infiltration scale was used; and whether the dressing was dated and timed) was evaluated to assess which was most consistently completed. The rate of compliance with the completion of the bundled elements was calculated and summarized by intervention period.

For Goal 1 (implementing an evidence-based care and maintenance bundle), Fisher's Exact tests were used to test for significant improvement ($\alpha < .05$) between pre- and post-bundle compliance rates. Paired t-tests (or Wilcoxon signed-rank test if not normally distributed) were planned to test the difference between the pre- and post-bundle compliance mean scores. For Goal 2, Chi-square tests for differences between pre- and post-correct response rates on the knowledge test were performed using logistic regression model for repeated measures. Goal 3

was evaluated using descriptive statistics to determine project costs and savings. Finally, the primary project aim of reducing the incidence of MRSA bacteremia was evaluated using crude estimates of pre- and post-implementation incidence rates for MRSA and were calculated using per 100 patients per year. All statistical analyses were conducted at a 5% significance level using R version 3.4 or higher (R Foundation for Statistical Computing, Vienna, Austria) and/or SAS version 9.4 or higher (SAS Institute Inc., Cary, NC).

Findings

The primary aim of this QI project was to evaluate the effectiveness of a multimodal intervention program for reducing the incidence of Methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia by achieving three goals: 1) implementing an evidenced-based care and maintenance bundle; 2) increasing the knowledge of the staff as it relates to the care and maintenance of peripheral intravenous catheters (PIVCs); and 3) providing a cost neutral or reduced cost solution for the health system to aid in achieving these goals. The care bundle was assessed by comparing PIV compliance and care rates before and after the intervention and by evaluating the change in the incidence rate of MRSA bacteremia before and after the intervention. Similarly, relevant knowledge gain was assessed by evaluating changes in the PIV test scores on a twelve-question tool administered before and after the intervention. Finally, the financial benefits of the intervention were assessed by comparing the number of IV catheters and IV dressing kits utilized in the three-month pre-intervention period and the implementation period.

Goal 1: Implementing an Evidenced-Based Care and Maintenance Bundle

The cohort of patients for which the PIV compliance and care audit was completed consisted of 297 participants both pre and post implementation. The pre- and post-compliance rates for the PIVC bundle are summarized in Table 1 and Figure 1. The results revealed improvement in overall compliance across all components of the intervention. More specifically, significant improvements were observed with respect to "Use of Disinfecting Cap," 'Dressing Dated and Timed," "Use of Infiltration Scale," and "Daily Bath and Linen Change." Statistical tests for significant improvements in pre- and post-compliance rates were performed using Fisher's Exact tests at a 5% significance level. No statistical test was conducted when the compliance rate was zero at pre-intervention period. The compliance score across all elements increased from a pre-compliance rate of zero to 77.8% post-compliance. Significant improvements at $\alpha < .05$ were noted for "Dressing Clean, Dry and Intact" ($p = .0380$), "Daily Bath and Linen Change" ($p = .0151$), and "Was the infiltration scale used?" ($p = .0346$).

The Wilcoxon signed-rank test was used to test the difference between the pre- and post-compliance mean scores. For the "All elements score," the pre-compliance mean was 34.5 ($SD = 14.93$) and the post-compliance mean was 92.5 ($SD = 14.88$). The improvement was found to be statistically significant, $p < .0001$, at an $\alpha < .05$ significance level.

Table 1

Rates of Compliance by Period of Intervention (pre vs. post)

Variables	Pre-Compliance	Post-Compliance	P-value
Dressing Clean, Dry and Intact [n (%)]			
Yes	249 (83.8)	267 (89.9)	0.0380
No	48 (16.2)	30 (10.1)	
Daily Bath and Linen Change [n (%)]			
Yes	207 (69.7)	270 (90.9)	0.0151
No	90 (30.3)	27 (9.1)	
Was the infiltration scale used? [n (%)]			
Yes	50 (16.8)	285 (96.0)	0.0346
No	247 (83.2)	12 (4.0)	
Is the dressing dated and timed? [n (%)]			
Yes	7 (2.4)	270 (90.9)	0.4905
No	290 (97.6)	27 (9.1)	
Use of disinfecting cap? [n (%)]			
Yes	0 (0.0)	281 (94.6)	n/a
No	297 (100)	16 (5.4)	
All elements completed [n (%)]			
Yes	0 (0.0)	231 (77.8)	n/a
No	297 (100)	66 (22.2)	
All elements Score			
n	297	297	
Mean (SD)	34.5 (14.93)	92.5 (14.88)	<.0001
Median	40.0	100.0	
Min - Max	0.0 - 60.0	40.0 - 100.0	

Tests for differences between pre- and post-compliance rates were performed using Fisher's Exact test.
Test for a difference between pre- and post-compliance mean scores was performed using Wilcoxon test.
A statistically significant difference is concluded if a p-value < 0.05.

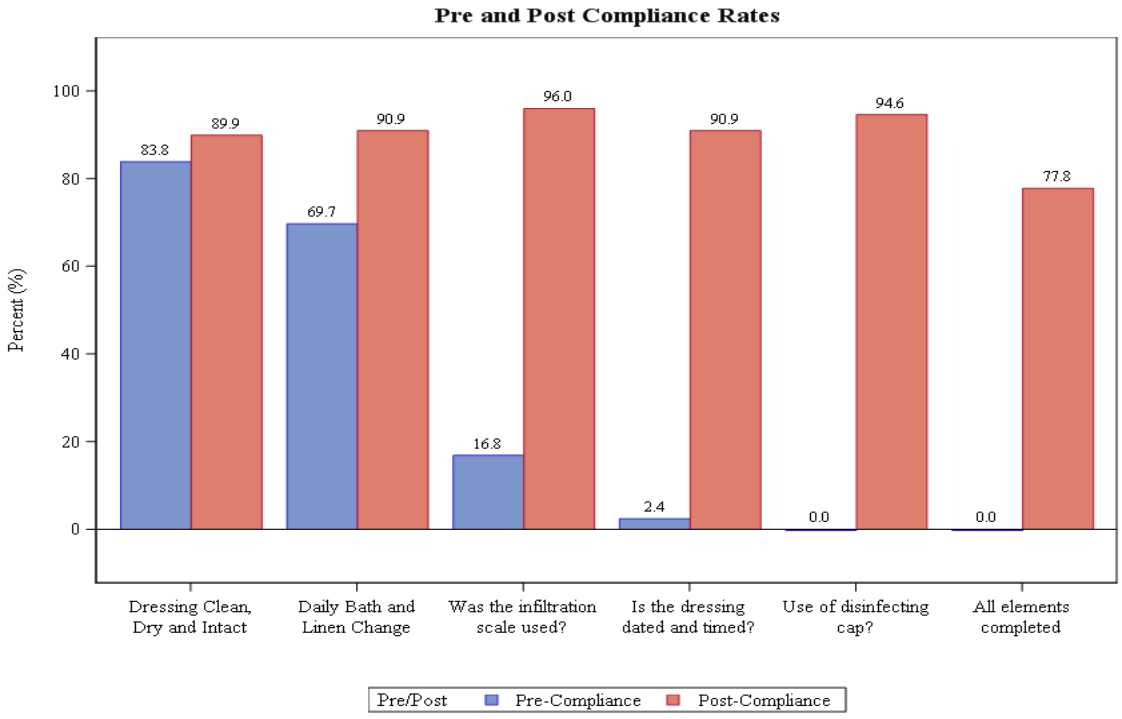

Figure 1. Pre and post compliance rates for the PIVC bundle components

Goal 2: Increasing the Knowledge of Staff

The cohort of registered nurses consisted of 122 participants from three care units. Among those, 111 (~91%) completed both pre- and post-intervention paired PIV knowledge tests. The summary results of the knowledge test scores are shown in Table 2. A t-test for a difference between pre- and post-knowledge mean scores was performed using a mixed model for repeated measures. The analysis did not show any evidence of significant differences between the pre and post total mean scores (p-value = 0.5215 > 0.05). The means of the pre- and post- total scores (SD) were 0.85 (0.296) and 0.87 (0.260), respectively, for a mean difference of only 0.02.

Table 2

Gain in PIVCs Knowledge by Period of Intervention (Pre vs. Post)

Question	Pre-Compliance	Post-Compliance	P-value
Phlebitis is a sign of blood vessel damage and can be caused by			
Correct Response	95 (77.9)	89 (88.1)	0.0377
Incorrect Response	27 (22.1)	12 (11.9)	
In which of the following situations should hand hygiene be performed?			
Correct Response	112 (91.8)	95 (94.1)	0.5079
Incorrect Response	10 (8.2)	6 (5.9)	
Dressings to PIVs sites are the first line of defense against infection and dislodgement. The dressing must be secure, clean, dry, and intact to achieve this.			
Correct Response	114 (93.4)	98 (97.0)	0.1990
Incorrect Response	8 (6.6)	3 (3.0)	
Infective phlebitis is caused by the introduction of bacteria into the vein. What are some causes of infective phlebitis? Select all that apply			
Correct Response	113 (92.6)	91 (90.1)	0.4685
Incorrect Response	9 (7.4)	10 (9.9)	
How are antibiotic-resistant pathogens most frequently spread from one patient to another in health care settings?			
Correct Response	74 (60.7)	63 (62.4)	0.8505
Incorrect Response	48 (39.3)	38 (37.6)	
You are coming on shift and making your first assessment of the day. The PIV site dressing is clean, dry, and intact. You flush the IV with saline and the patient states 'that's a little tender'. You notice that the insertion site looks a little red and swollen. What are your next steps?			
Correct Response	101 (82.8)	83 (82.2)	0.7972
Incorrect Response	21 (17.2)	18 (17.8)	
A PIVC should be removed:			
Correct Response	97 (79.5)	87 (86.1)	0.1681
Incorrect Response	25 (20.5)	14 (13.9)	
Which statement is false regarding our policy on peripheral IV site care and maintenance?			
Correct Response	94 (77.0)	81 (80.2)	0.6313
Incorrect Response	28 (23.0)	20 (19.8)	
Which statements are false regarding IV site assessment?			
Correct Response	41 (33.6)	35 (34.7)	0.8653
Incorrect Response	81 (66.4)	66 (65.3)	
Identify the false statement(s).			
Correct Response	100 (82.0)	88 (87.1)	0.2907
Incorrect Response	22 (18.0)	13 (12.9)	

Note. Chi-square tests for differences between pre- and post-correct response rates were performed using logistic regression model for repeated measures T-test for a difference between pre- and post-knowledge mean scores was performed using mixed model for repeated measures. A statistically significant difference is concluded if a p-value < 0.05.

Chi-square tests for differences between pre- and post-correct response rates were performed using logistic regression model (GEE-type). The analysis of the twelve individual questions showed significant improvement for the following items:

- "Phlebitis is a sign of blood vessel damage and can be caused by" (p-value = 0.0377 < 0.05),
- "What phlebitis grade would be attributed to the assessment of the PIVC site below?" (p-value = 0.0235 < 0.05), and
- "What would be your course of action as the nurse caring for this patient? Select all that apply" (p-value = 0.0117 < 0.05).

The percentage of participants who responded correctly to each of these questions was improved by approximately 10%. For the remaining questions, the improvement was less than 5%.

Goal 3: Cost Neutral or Reduced Cost Solution

The number of PIVCs used across the three care units during the 3-month pre-intervention timeframe was 3,716 compared to 2,570 during the post intervention timeframe, which represents a 30.84% reduction in use. Based on the contractual cost of our PIVCs at $1.73/ea. the estimated savings for this product was $1982.58. Similarly, PIVC start kit use was reduced from 3,217 pre-intervention to 1,517 post-intervention, representing a 52.84% reduction. Although a reduction in the amount of kits used was significant, the increase in the cost of the kit from $0.99 to $2.12/ea. reflected in an increase $31.16. Overall a savings of $1951.42 was realized. One limitation of this QI project was that it occurred during the transition from one materials management inventory system to another within the health system. Thus, the accuracy of the post-supply numbers of IV catheters and IV start kits could be slightly skewed. Therefore,

an accurate assessment of savings cannot be provided, although there was a significant decrease in product use during the post-implementation period. The average dwell time for the PIVCs pre-intervention was 2.525 days, compared to 2.625 days post-intervention.

Primary Project Aim: Reduced Incidence of MRSA Bacteremia

Crude estimates of pre- and post-implementation incidence rates of MRSA bacteremia were calculated per 100 patients per year using the formula below:

$$\text{IR} = \frac{\text{Number of ORSA events x } 365.25}{\text{Total patients days exposure}} \text{x} 100$$

The estimated incidence rates before the intervention was 5.07 per 100 patients-year compared to 1.73 per 100 patients-year after the intervention. A difference of -3.34 incidences of MRSA bacteremia per 100 patients-year. The test for the difference between the pre and post incidence rates was performed by fitting a Poisson regression model. The results of the Poisson regression model are summarized in Table 3. The estimated rate difference was –3.34 per 100 patients-year with 95% confidence interval of (-3.33, 10.01). This represents a 66% reduction (0.658 = 1- 1.73/5.07) in the number of MRSA incidences. However, this reduction was not found to be statistically significant at 5% significance level (p-value = 0.3269 > 0.05).

Table 3

Comparisons between pre- and post- ORSA incidence rates per 100 patients-year

	Rate (100 patients-year)	StdErr	95% Lower	95% Upper	P-value	Significantly Different?
Pre	5.07	2.31	1.43	17.94	.	
Post	1.73	1.45	0.17	17.68	.	
Difference (Post - Pre)	3.34	3.40	-3.33	10.01	0.3269	No

IR: Incidence Rate per 100 patients-year StdErr: Standard Error
Test for the difference between pre and post rates was conducted by fitting a Poisson regression model
Significant difference is demonstrated if p-value < 0.05.

Based on the estimated $189,581 minimum spend for MRSA infections in FY2018 and the 66% reduction realized through this intervention, the hospital system would have saved $125,123 in treatment costs for the fiscal year.

The implementation of this QI project demonstrated a significant increase in compliance rates post-intervention. Although no overall significant gain in knowledge was observed, there were gains in knowledge on three specific items: "Phlebitis is a sign of blood vessel damage and can be caused by," "What phlebitis grade would be attributed to the assessment of the PIVC site below?," and "What would be your course of action as the nurse caring for this patient? Select all that apply." A reduction in the number of supplies used and, thus, cost was shown; however, the increased dwell time was only minimal. The results also showed a reduction in the number of MRSA incidences observed after the intervention. The average number of incidences (95% CI) before the intervention was 5.07 (0.72, 35.93) compared to 1.73 (0.05, 63.56) after the intervention, for an estimated reduction of 65%. However, no statistical significance was demonstrated. Though the findings are not statistically significant, they are clinically significant from a quality and patient safety perspective. These findings suggest that continued implementation and hardwiring of this practice bundle could result in decreased costs in terms of

supplies and money spent on treatment of bacteremia as well as increased institutional knowledge.

Recommendations and Implications

PIVCs are the most common invasive procedure performed worldwide in the hospital setting and are associated with multiple complications and failure rates of up to 50% (Helm, Klausner, Klemperer, Flint, & Huang, 2019). One of the causative factors associated with the development of phlebitis and thus catheter failure and or infection is related to caregiver insertion technique. Specific training on PIVC insertion technique including IV site selection has been associated with a lower incidence of phlebitis and failure (Helm, Klausner, Klemperer, Flint, & Huang, 2019). Future improvement strategies would be enhanced by coupling IV insertion technique with standardization of catheter use and care after insertion. Although not quantified in this work, the pain, dissatisfaction, venous depletion and prolonged length of care for the patient should be considered as a valuable added benefit.

PIVCs are a standard of care in hospital settings and, when not cared for properly or when used incorrectly, may be a significant source of infections, especially of MRSA. The use of a bundled set of interventions has resulted in a reduction of MRSA in this small test of change across three hospital units over a 3-month time frame. The results of this QI project suggest that the implementation of a bundled approach to the care and maintenance of PIVCs is clinically effective at reducing the incidence of MRSA bloodstream infections. Because the implementation resulted in decreased incidences of MRSA bacteremia, the positive impact on decreased morbidity and mortality must be considered as well. However, because the change was not statistically significant, continued observation and auditing is needed to demonstrate the continued efficacy of the intervention. Additionally, since the use of PIVCs is a global issue

impacting numerous hospitalized patients annually, if continued efficacy is demonstrated, this work should be disseminated and shared for broader adoption.

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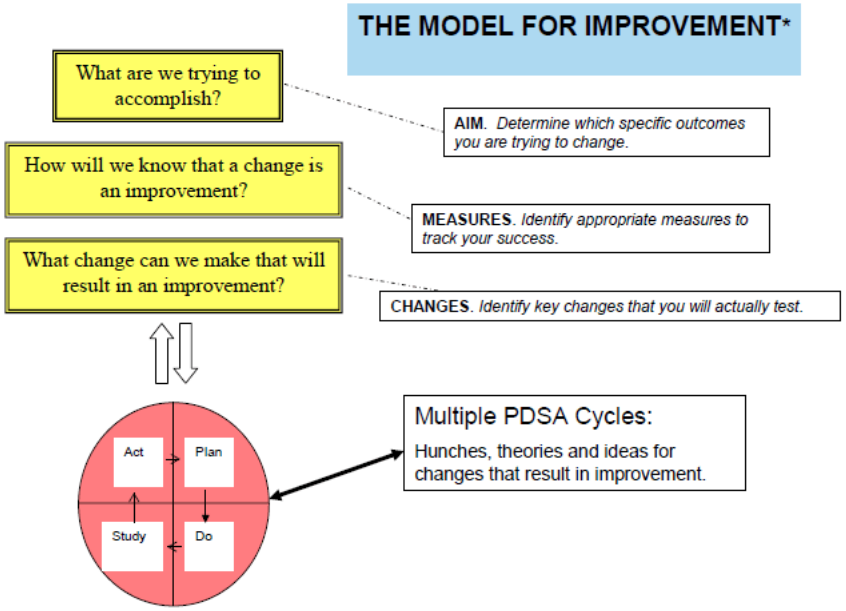
Appendix A

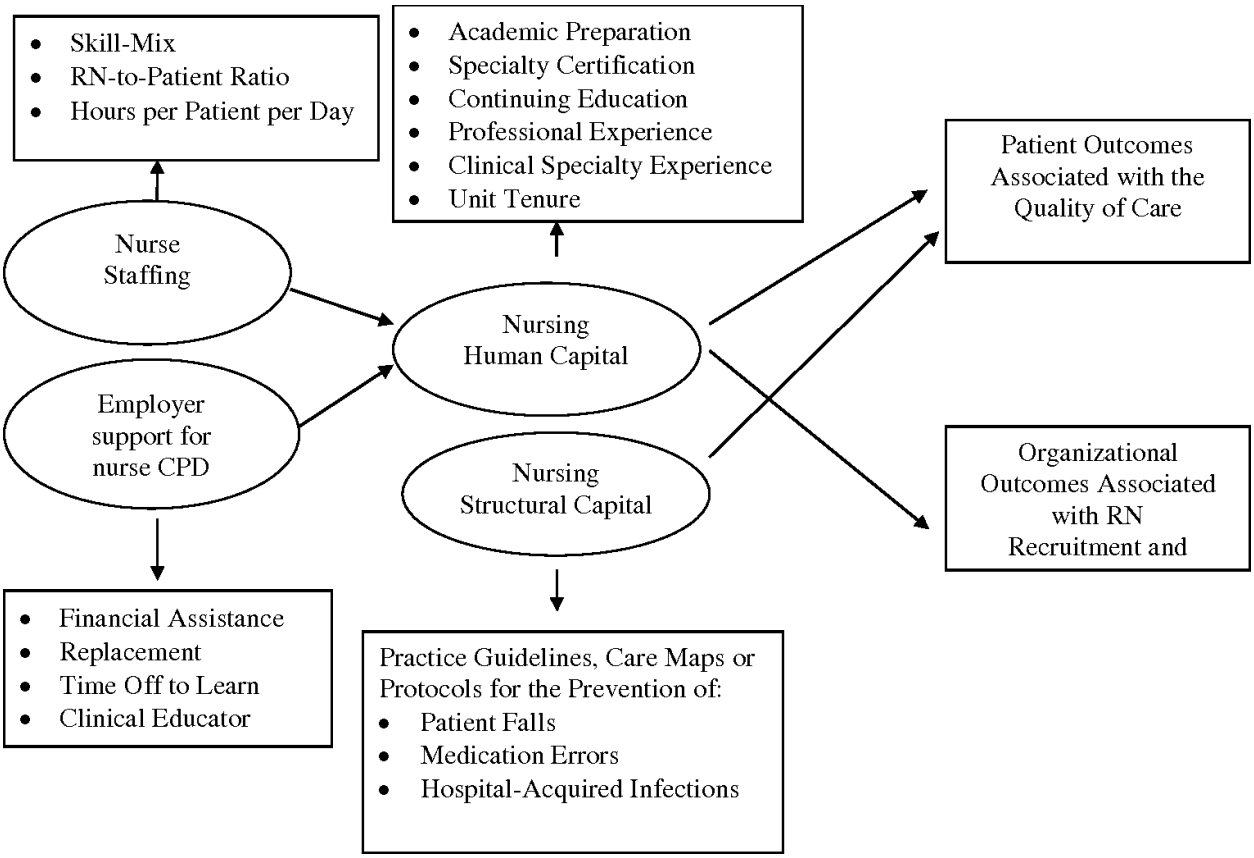
The Model for Improvement



Source: Langley, et al. (2009)

Appendix B

Nursing Intellectual Capital Theory



Source: Covell and Sidani (2017).

Appendix C

Audit Tool

Unit: Date:										
Select site for PIV (circle) or ML	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other	UA, AC, FA, Wrist, Hand, ML, EJ, Other
PIV gauge (circle)	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines	18G, 20G, 22G, 24G NA Midlines
Was the Infiltration Scale/Grade 1/greater	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a
Are Curos Caps present at every access site and Detached tubing?	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a
Was dressing changed within the past 7 days?	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a
Is dressing dated	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a
Does the visualized site match the documented site?	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a
Was the infiltration scale and grade documente	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a

d at least once in the previous shift										
Is there documentation of a daily bath and linen change	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a	YES NO n/a

Appendix D

Sample Size Table

Required Sample Size†

Population Size	Confidence = 95% Margin of Error				Confidence = 99% Margin of Error			
	5.0%	3.5%	2.5%	1.0%	5.0%	3.5%	2.5%	1.0%
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1,000	278	440	606	906	399	575	727	943
1,200	291	474	674	1067	427	636	827	1119
1,500	306	515	759	1297	460	712	959	1376
2,000	322	563	869	1655	498	808	1141	1785
2,500	333	597	952	1984	524	879	1288	2173
3,500	346	641	1068	2565	558	977	1510	2890
5,000	357	678	1176	3288	586	1066	1734	3842
7,500	365	710	1275	4211	610	1147	1960	5165
10,000	370	727	1332	4899	622	1193	2098	6239
25,000	378	760	1448	6939	646	1285	2399	9972
50,000	381	772	1491	8056	655	1318	2520	12455
75,000	382	776	1506	8514	658	1330	2563	13583
100,000	383	778	1513	8762	659	1336	2585	14227
250,000	384	782	1527	9248	662	1347	2626	15555
500,000	384	783	1532	9423	663	1350	2640	16055
1,000,000	384	783	1534	9512	663	1352	2647	16317
2,500,000	384	784	1536	9567	663	1353	2651	16478
10,000,000	384	784	1536	9594	663	1354	2653	16560
100,000,000	384	784	1537	9603	663	1354	2654	16584
300,000,000	384	784	1537	9603	663	1354	2654	16586

Source: The Research Advisors (2006)

Appendix E

QI Project Timeline

Activity	Baseline			Implementation		Evaluation		
Month	1	2	3	4		5	6	7
Meet with key stakeholders		X						
PIVC assessments, chart audits	X	X	X			X	X	X
BSI data	X	X	X	X		X	X	X
Education sessions				X			X	
Kits rolled out on units				X				
Round on staff				X		X	X	X

Appendix F

Post-Test

HealthStream Post-Test Authoring Template

Directions: Use the following format for authoring multiple-choice and/or True/False question assessments to be programmed in HealthStream. Place two asterisks immediately following the correct answer, as shown below. Do not add periods to answers unless they include a complete sentence.

Name of Course this Post-Test will be added to: __ Pre/Post Test for PLABSI education__

Minimum Passing Score: (ex: 85%)

_____

1. Phlebitis is a sign of blood vessel damage and can be caused by:

   A. The osmolarity of a solution

   B. Trauma at insertion site from catheter moving in and out of vein or from insertion

   C. Microorganisms contaminating the device

   D. Improper disinfection of the skin prior to insertion

   E. The type of IV tubing used

   - B and E
   - A, B and D
   - B and D
   - A, B, C, and D **

2. In which of the following situations should hand hygiene be performed?

   A. Before having direct contact with a patient

   B. Before inserting an invasive device (e.g., intravascular catheter, Foley catheter)

C. When moving from a contaminated body site to a clean body site during an episode of patient care

D. After having direct contact with a patient or with items in the immediate vicinity of the patient

E. After removing gloves

- B and E
- A, B and D
- B, D and E
- All of the above **

3. Dressings to PIVs sites are the first line of defence against infection and dislodgement. The dressing must be secure, clean, dry, and intact to achieve this.

- True **
- False

4. Infective phlebitis is caused by the introduction of bacteria into the vein. What are some causes of infective phlebitis? Select all that apply

a. Failing to disinfect the injection site of your PIV prior to injection

b. Looping the IV tubing into one of its free ports until the next time you need it

c. Washing your hands prior to any manipulation of the PIV site

d. Cleansing the skin with antiseptic prior to cannula insertion

- A and B**
- A, B and D
- C and D
- All of the above

5. How are antibiotic-resistant pathogens most frequently spread from one patient to another in health care settings?

A. Airborne spread resulting from patients coughing or sneezing

B. Patients coming in contact with contaminated equipment

C. From one patient to another via the contaminated hands of clinical staff **

D. Poor environmental maintenance

6. You are coming on shift and making your first assessment of the day. The PIV site dressing is clean, dry, and intact. You flush the IV with saline and the patient states "that's a little tender". You notice that the insertion site looks a little red and swollen. What are your next steps?

A. Document your findings and continue to assess.

B. Remove the cannula and restart the IV. **

C. Call the physician and let him know the site is infected.

D. Ask the charge nurse to come in and assess for a second opinion.

7. A PIVC should be removed:
   A. When the IV site is free of any complications-Grade 0
   B. Only when the patient complains of pain at site-Grade 2
   C. Only when the IV site is assessed as Grade 3 or 4
   D. For Phlebitis/Infiltration assessed as Grade 1 or above

- B and E
- A, B and D
- B and D
- D **

8. Which statement is false regarding our policy on peripheral IV site care and maintenance?

A. A staff member should not attempt venepuncture more than twice on any patient.

B. Dressing changes should be performed every 7 days unless the dressing is damp, loosened, or visibly soiled.

C. IV sites do not need to be labelled with date of start, gauge of catheter, and initials of person starting IV if it is recorded in the EMR. **

D. Change the vascular access site as soon as possible when adherence to aseptic technique cannot be ensured. Examples include IVs started during medical emergency, unsecured catheters, and unlabelled IVs)

9. Which statements are false regarding IV site assessment?

A. The condition of the IV insertion site and surrounding tissue should be monitored and documented using the phlebitis/infiltration scale.

B. The condition of the IV insertion site and surrounding tissue should be monitored and documented every 2 hours for continuous infusions

C. The condition of the IV insertion site and surrounding tissue should be monitored and documented every 4 hours for intermittent infusions

D. Pain, erythema, edema, or drainage should be closely monitored, and PIV should only be removed after MD evaluation.

- B and E
- A, B and D
- B and D
- D **

10. Identify the false statement(s).

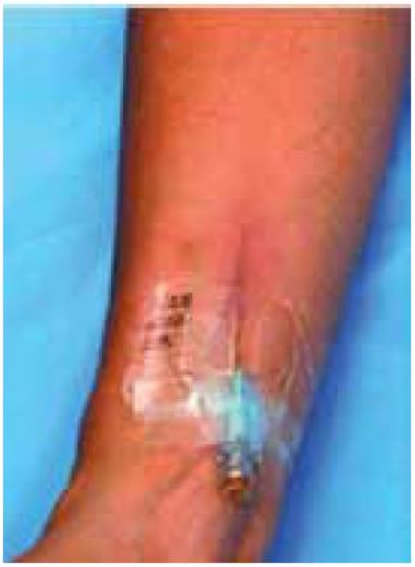
A. Patients with any IV access into the bloodstream are at risk for a blood stream infection

B. Patients should have as many IV access points as possible (especially in the ICU setting) **

C. If a PIVC has not been used in 24 hours, it should be removed.

D. Daily baths and linen changes are a part of the care plan for patients in the acute care setting

11. What phlebitis grade would be attributed to the assessment of the PIVC site below?



A. Grade 1

B. Grade 2

C. Grade 3 **

D. Grade 4

12. What would be your course of action as the nurse caring for this patient? Select all that apply.

A. Remove PIVC

B. Complete STARS report

C. Insert another PIVC

D. Elevate affected site

E. Document actions in EMR

- B and E
- A, B and D

- B and D
- A, B, D, and E **