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APPROPRIATENESS OF VASCULAR ACCESS DEVICE SELECTION

A Project Paper

by

Ashlee Viveiros

Rhode Island College

Executive Summary

Central venous access devices (CVADs) are associated with serious complications, including central line associated bloodstream infection (CLABSI), that place patients at risk for poor outcomes and are costly for hospital systems. Research suggests great variability of CVAD use in hospitals including overuse and inappropriate use of these devices which places patients at unnecessary risk for complications. Each unique patient situation involves multiple characteristics that adds complexity to their hospitalization. Clinicians make decisions regarding line selection often during emergent situations without the appropriate level of evidence to support this decision, which results in inconsistencies and variations in the use of CVADs. Vascular access nurses, specialized clinicians who place and maintain vascular access devices (VADs) in hospitalized patients, are often involved in decision making regarding VAD use. Providing these specialized clinicians with the latest evidence-based decision support tools and the knowledge needed to interpret this information to determine the most appropriate VAD for an individual patient may impact VAD utilization. Empowering vascular access nurses to appropriately evaluate and decide if a patient meets the criteria for CVAD insertion prior to placement could prevent unnecessary exposure to potentially dangerous and costly complications. The proposed project objectives include introducing an evidence-based guideline for use by the vascular access team to support VAD selection for hospitalized adult patients at a large academic medical center. Decision support guidelines are composed of evidence-based recommendations from Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) resources. The algorithms to be implemented address various complex patient scenarios that challenge clinicians when

choosing the most appropriate VAD. Project goals include improving appropriateness of VAD selection through recommendations from vascular access nurses using MAGIC resources as evidence-based guidelines in clinical decision making. Achieving these goals may result in a decrease in inpatient CVAD use and a reduction in serious complications associated with CVADs. Objectives are aimed at improving the quality of patient care by using the latest evidence for vascular access recommendations. Improved quality of care can reduce health care costs by preventing serious and life-threatening complications that prolong the hospital length of stay and require additional unnecessary therapies and hospital readmissions.

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Appropriateness of Vascular Access Device Selection

Background/Statement of the Problem

Vascular access device (VAD) placement is the most common procedure performed in hospitalized patients (Chopra, Kuhn, Ratz, Flanders, & Krein, 2016). VADs are catheters inserted into the peripheral or central vessels for the purposes of monitoring, diagnostic procedures, or therapeutic administration of medications and fluids. Central venous access devices (CVADs) are placed in hospitalized patients for a variety of reasons including administration of vesicants such as chemotherapy or parental nutrition, administration of long-term antibiotics, hemodynamic monitoring for critically ill patients, frequent blood sampling, and establishing a secure access for patients with poor or inaccessible venous access. CVADs are associated with serious complications, including central line associated bloodstream infection (CLABSI) and deep vein thrombosis (DVT), that place patients at risk for poor outcomes and are costly for patients and hospitals. Less serious complications associated with these lines include vascular occlusions, dislodgements, and insertion site infection (Chopra et al., 2015).

One type of CVAD, the peripherally inserted central catheter (PICC) has increased in popularity in recent years due to benefits including cost-effectiveness and convenience of use as patients can be discharged home with these devices to complete treatment regimens (Chopra et al., 2015). PICCs also offer decreased risk during placement, when compared to other CVADs, with use of insertion techniques that can be safely performed by vascular access nurse teams at the patient's bedside. PICCs, like other CVADs, are associated with both serious and less serious complications. Research suggests variability of PICC use in hospitals including overuse and inappropriate use of

these lines that places patients at unnecessary risk for complications. Appropriate indications for PICC placement in the literature establish criteria for PICC line insertion that is critical to preventing unnecessary exposure to potentially dangerous and costly complications (Chopra et al., 2015).

A midline catheter (MC), a type of VAD that is not considered a central catheter, is inserted peripherally into the arm and extends 8-20 cm in length to or below the axillary vein (Adams, Little, Vinsant, & Khandelwal, 2016). MCs are associated with significantly lower rates of the serious complications, including CLABSI and DVT, than PICCs. MCs offer a longer duration of use, up to 28 days, than standard peripheral intravenous catheters (PIV), providing the benefit of less frequent venipuncture for patients. MCs offer a potential for decreased complications associated with central lines and a cost-effective alternative for long-term intravenous (IV) therapy (Adams et al., 2016). The current guidelines recommend that infusions through MCs have a pH between 5 and 9 and osmolarity of < 600 mOsm, however some clinicians remain concerned about the administration of vesicants through MCs as this was previously contraindicated in the literature. Research now demonstrates safe administration of these medications through a MC and recommends these medications no longer be an indication for central line access (Adams et al., 2016).

The AccuCath Intravenous Catheter System, a type of ultrasound guided peripheral IV (USGP IV) is a recent addition to VAD options. USGP IVs offers a longer dwell time than conventional PIVs but are shorter in length than MCs. These USGP IVs are placed with a retractable coiled tip guidewire to increase first attempt insertion success rates. Current research demonstrates an increased rate of first attempt placement

success, reduced complication rates, reduced costs, and increased patient satisfaction associated with extended dwell time when compared to conventional PIVs (Idemoto, Rowbottom, Reynolds, & Hikman, 2014).

PICCs, traditionally placed by interventional radiologists, are now primarily placed by dedicated vascular access nurse teams in hospitals (Chopra et al., 2016). The growth of the vascular access nurse specialty has contributed to the rapid growth of PICC use, as these specialized teams offer benefits of high insertion success rates and decreased costs associated with placement. Vascular access nurses are involved in the placement of many VADs in hospitals, having vascular access nurse practice routed in the principles of an evidence-based criteria for decision making provides an opportunity for improved device selection and interprofessional collaboration.

Choosing the most appropriate line for a patient can be difficult as each patient situation includes multiple characteristics that create a complex scenario during hospitalization. Clinicians make decisions about VAD selection frequently under urgent circumstances and often without the necessary level of evidence to support the decision-making process. This lack of decision support results in inconsistencies between practice and inappropriate use of CVADs in hospitalized adults (Chopra et al., 2015). The MAGIC decision criteria, developed by an international panel of experts, establishes a guideline for indications and appropriate use of VADs by clinicians. This guideline supports the clinician to determine the most appropriate VAD for an individual patient to minimize risk associated with unnecessary CVAD use, particularly PICCs. Providing clinicians with necessary VAD decision support is essential to decreasing unnecessary risk for patients and associated costs.

Purpose Statement

The purpose of this project is to equip vascular access nurses with the Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) evidence-based guidelines and knowledge necessary to support clinical decision making in VAD selection.

Literature Review

A comprehensive review of relevant literature from 2008 to 2019 was performed using CINAHL (Cumulative Index to Nursing and Allied Health Literature), Ovid, and PubMed databases. Keywords searched included venous access device, central venous access device, central venous catheter, peripherally inserted central catheter, midline catheter, ultrasound-guided peripheral intravenous catheter, peripheral intravascular catheter, peripheral intravenous line, vascular access nursing, and clinical decision support. Articles not available in English and not including hospitalized adult populations were excluded.

Patient Safety and Quality

According to the Centers for Disease Control and Prevention (CDC) (2011a) healthcare-associated infections (HAIs) are infections that patients can contract while receiving medical care that negatively impact patient outcomes and increase healthcare costs. HAIs caused by bacterial, viral, and fungal pathogens, can develop during any stage of patient care and across all health care settings. HAIs include central line-associated blood stream infections (CLABSIs), catheter-associated urinary tract infections, surgical site infections, and ventilator-associated events. CLABSIs are infections occurring when pathogens enter the bloodstream via CVADs (CDC, 2011a). CVADs are intravenous catheters placed in large vessels of the chest, groin, or neck for a

variety of treatments or hemodynamic monitoring. CLABSI are preventable, but still occur across health care settings and result in unnecessary death and billions of dollars in additional health care costs each year (CDC, 2011a).

Defined by the CDC (2019), a primary bloodstream infection is an infection of the bloodstream confirmed by laboratory that is not secondary to another infection in the body at a different site. A central line, or CVAD, is defined by the CDC (2019) as an intravascular catheter terminating in a vessel close to the heart or another great vessel that is used for infusions, hemodynamic monitoring, or blood sample. A CLABSI is defined as a bloodstream infection with an eligible bloodstream infection organism identified and confirmed by laboratory test, when an eligible device is present on the day of or day before infection is detected (CDC, 2019). Eligible bloodstream infection organisms are all organisms not excluded for use in meeting criteria for laboratory confirmed bloodstream infection. Eligible CVADs are defined as a CVAD that has been accessed for use and is present for more than two consecutive days in an inpatient location during the current admission (CDC, 2019). These eligible CVADs are eligible for CLABSI events until patient discharge or removal from patient's body.

Significant progress in HAI prevention has been made recently, specifically hospitals across the U.S. have seen a 46% decrease in CLABSI from 2008-2013 (CDC, 2018). It is estimated that over 30,000 CLABSI still occur each year. Health care providers must adhere to strict evidence-based procedures during placement and maintenance care of CVADs to reduce the risk of CLABSI occurrence (CDC, 2018). According to the CDC (2011b), CLABSI are preventable through adherence to strict insertion and care techniques described in CDC guidelines. This document, prepared by

the CDC, serves to guide health care professionals through evidence-based practice recommendations to prevent CLABSI. Recommendation highlights include emphasis on appropriate training and education of providers, sterile technique during insertion, use of antiseptic/antibiotic impregnated dressings, and use of CLABSI prevention bundle techniques (CDC, 2011b).

PICCs

Secure vascular access is essential to care of most hospitalized patients.

Advances in medical equipment technology have produced several VADs that offer improved benefits for patients, including the ability to receive necessary intravenous therapy outside of hospital. The peripherally inserted central catheter (PICC), developed in the 1970s, is inserted peripherally then threaded to centralized veins and therefore are categorized as a CVAD (Chopra, Flanders, & Saint, 2012). PICCs have gained popularity as a potentially safer alternative to centrally inserted central catheters (CICCs) for hospitalized patients as they have demonstrated reassuring data for decreased CLABSI incidence when providers worked actively to remove unnecessary PICCs in practice (Al Raiy et al., 2010; Gunst et al., 2011).

PICCs have demonstrated appealing advantages over CICCs for patients and providers alike. Specialized vascular access nurses are trained to safely insert PICCs at the bedside to decrease the cost of previously required interventional radiology procedures (Meyer, 2012). Patient satisfaction and comfort are positively impacted as the PICC can be placed in a timely fashion and does not require the patient to leave their room (Meyer, 2012). PICCs offer additional patient satisfaction opportunities as they allow for blood draw for routine labs, avoiding painful and frequent phlebotomy draws

(Chopra et al., 2012). Due to peripheral insertion techniques used, PICCs are safer to insert than other CICC and can remain safely in place for long periods of time and avoid routine peripheral access replacement (Chopra et al., 2012). PICCs decrease costs by significantly decreasing hospital length of stay as patients can be discharged with a PICC in place and continue intravenous therapy after discharge (Chopra et al., 2012). These advantages have made PICCs the most common CVAD used for patients outside of intensive care units (ICUs) (Chopra et al., 2012).

As use of PICCs has grown worldwide, concerns of associated complications, including CLABSI, and inconsistent use have appeared in the literature (Chopra et al., 2015). As PICC use grew, research related to PICC use and associated complications was limited to single-site studies among ideal populations. This limited research supported continued PICC use and lacked an accurate comparison of complication rates compared to other CVADs. Evidence-based guidelines regarding appropriate indications for PICC use given various clinical scenarios were not available in the literature (Chopra et al., 2015). Without research and evidence-based guidelines supporting best practice, variability and inappropriate PICC use flourished.

Increase popularity in PICC use may be related to perceptions that PICCs are a safe alternative to other CVADs (Chopra et al., 2012). Early studies suggesting PICCs may be associated with lower rates CLABSI when compared to other CVADs supported provider preferences to these devices. As more research was conducted, evidence suggesting PICC-related complications may be multifactorial emerged (Chopra et al., 2012). Research exploring patterns of use and practice variation in use of PICCs is

limited. Given this gap in evidence, providers have limited resources to support best practice related to PICC use.

Use of PICCs

PICC placement in hospitalized patients often requires an order from a provider and are placed for a variety of indications. Understanding the practice of hospital-based providers, who make up a large portion of providers of inpatient care related to decisions for PICC insertion can provide useful information to understand current PICC use in hospitals. Chopra et al. (2013) conducted a web-based survey of a convenience sample of 227 hospitalists from five large healthcare systems in Michigan to explore provider practices related to PICC use. The survey was developed from an evidence-based framework of PICC-related complications categorized into the domains of hospitalist experience, knowledge, opinions, and practice regarding PICC use. The survey was pilot tested with a group of randomly selected hospitalists. A survey response rate of 63% was obtained with 144 respondents completing the survey for the study (Chopra et al., 2013).

Hospitalists reported long-term IV antibiotic treatment as the most common indication for PICC placement, followed by difficult venous access (Chopra et al., 2013). Hospitalists reported caring for patients who had PICCs and PIVs in place at the same time and 87% of participants reported inserting a PICC because a patient specifically requested a PICC for difficult venous access. Only 35% of participants reported selecting the lowest number of lumens possible when ordering a PICC. Sixty-nine percent of hospitalists felt that PICCs were safer and more efficient than CICC because they could stay in place longer and thought they were associated with a lower risk of infection. Seventy-four percent of participants reported patients preferred PICCs to avoid pain with

scheduled PIV changes and phlebotomy, and 65% stated PICCs were more convenient because they could be placed by vascular access nursing teams. Hospitalists reported that PICCs may be placed inappropriately in their hospitals and 84% agreed that it was appropriate to place a PICC if other forms of peripheral access could not be obtained. Seventy-eight percent of hospitalists stated that the increase in vascular access nurse teams had increased the use of PICCs in hospitalized patients (Chopra et al., 2013).

The survey results demonstrated significant variation in reported practice, opinion, and knowledge related to PICC use among hospitalists (Chopra et al., 2013). Despite the evidence associating PICCs with serious complications, PICC use in hospitals is not decreasing. Hospitalists reported keeping PICCs in place that are no longer indicated. Hospitalists who reported providing direct patient care and practicing for less than five years were more likely to be aware of the inappropriate use of PICCs and acknowledge the influence of vascular access nurse teams on PICC placement rates (Chopra et al., 2013). Understanding the practice of hospitalists in relation to PICC use is essential to impacting VAD selection as these providers are often responsible for PICC selection and orders for placement and removal. Survey results demonstrated several gaps between evidence-based PICC indications and current practice by hospitalists (Chopra et al., 2013). Clinical knowledge and integration of evidence-based criteria to guide vascular access device selection is needed to standardize clinical decision making and prevent unnecessary device use and associated complications.

Midline Catheters

Pathak et al. (2015) conducted a retrospective cohort study to evaluate the effect of MC use in place of CVADs on CLABSI rates on a ventilator dependent unit where

patients required long-term care outside of a nursing home. The researchers used two separate study periods, including one year of catheter days before MCs were implemented (Group A) and one year of catheter days after MCs were introduced (Group B). The population studied had the highest catheter days per unit, likely related to the unit's greater than average length of stay and reported frequent venous access difficulties. CVADs were placed on this unit for long-term use, challenging venous access, blood draws, antibiotic administration, blood transfusions, and diagnostic procedures (Pathak et al., 2015).

Researchers collected data pertaining to catheter days, CLABSI rate per 1000 catheter days, type of bacteria associated with CLABSI, and date of culture from the infection control department (Pathak et al., 2015). During the time period between the two collection groups, nurses and medicine residents were trained to insert MCs to replace CVADs whenever indicated as a new practice intervention. Practice changes with MC introduction included replacing any femoral CVAD with a MC, replacing all CVADs with MCs for patients not on total parenteral nutrition (TPN) or an inotropic agent, replacing CVADs in place longer than one week with MCs, placing MCs for patients being discharged to nursing home with IV antibiotics, and discontinuing MCs at dwell duration limit of 28 days or once access was no longer needed. Catheter days, calculated as the number of CVADs on the unit every day, and CLABSI rate were compared between the two groups and reported as CLABSI rate per 1000 catheter days (Pathak et al., 2015).

Catheter days decreased significantly after the MC program was introduced with 2408 catheter days and 3058 inpatient days in Group A and 1521 catheter days with 2948

inpatient days for the Group B study period. A statistically significant decrease in CLABSI rate was observed with a rate of 3.32 per 1000 (Group A) to 0 per 1000 catheter days (Group B). Two patients developed phlebitis with MCs, no blood stream infections were found to be associated with MCs, and one patient developed a pneumothorax that was associated with CVAD insertion (Pathak et al., 2015).

The researchers note the significance of an average catheter dwell time of greater than 9 days as a factor to CLABSI development as described by the CDC recommendations. Authors contribute reduction of CLASBI rates to elimination of risks associated with long dwell time, CVAD dressing changes, and routine catheter care (Pathak et al., 2015). Limitations of this study include retrospective design limited to one unit with a specific patient population, limiting the generalizability of findings. The large sample size is beneficial, but two separate study periods allow for confounding factors.

Moureau, Sigl, and Hill (2015) performed a 2-site retrospective study to provide a descriptive review of two hospital MC programs that were successfully implemented into the vascular access practice. A convenience sample of hospitals included two acute care facilities with a MC program including bedside insertion and specific policies in place for a period of time greater than two years. The two participating hospitals submitted policies and program outlines for review by the researchers. Vascular access team members and leaders from the sites were included as participants in the study. Participants were observed and interviewed about program structure, program development, device use, barriers and solutions, midline indication guidelines, infection rates, and staff education regarding program. Results were used to describe the process used to develop a midline catheter program (Moureau et al., 2015).

The first site was an urban located 400-bed Magnet hospital, designated as a level-1 trauma teaching hospital in the Midwest. The hospital's infection control department had recently provided nurses with a refresher of central line bundle education and began evaluating criteria for each patient individually before central line placement. The department also introduced the use of ultrasound for difficult access when placing PIVs and MCs in an effort to reduce their CLABSI rate (Moureau et al., 2015). The hospital formed a vascular access nursing team to insert PICCs. A MC protocol, instituted to allow MC insertion by the vascular access team without a provider's order, included device selection, patient evaluation, and MC insertion. When the team encountered difficulty with device placement, they adjusted device and manufacturer selection and insertion techniques as problems were identified and device insertion success rates increased among clinicians. Patients with MCs were assessed daily for complications associated with the device and duration of the line dwelling. Authors reported that education of vascular access nurses was critical to success of the new policy and practice change (Moureau et al., 2015).

A 215-bed hospital in Georgia served as the second study site. Hospital administrators were concerned with the high number of PICC use in their facility and started a MC program. PICCs were currently placed by the cardiac catheterization team at a rate of 60-80 per month. The facility began the MC program in 2011 and struggled with line placement success initially. After reaching out to the manufacturer's representatives for assistance, they were able to develop consistent placement performance with 80-100 MCs placed per month. The hospital's goal was to increase MC

use and reduce CVAD use, remove existing CVADs and replace with MC before the ICU patient is transferred to general medical or surgical unit (Moureau et al., 2015).

The first hospital saw a 58% reduction in PICC use from 2012 to 2014 with overall CVAD use down to 0.23/100 device-days from 0.48/100 device-days. The second hospital demonstrated an increase from 200 MCs placed in 2012 to 960 placed in 2014. Both hospitals considered MC selection as a nurse-driven intervention not requiring provider order. An increase in education of bedside nurses was associated with increase in compliance in placing the most appropriate catheter for patients. Both hospitals reported zero MC-associated infections over the study period, and the second hospital reported zero CLABSI in 2014. CLABSI rates decreased by 78% for the first hospital with an estimated cost savings of \$531,570. The authors also noted projected decreased costs associated less need for x-ray for placement confirmation, costs for eliminating occlusions with thrombolytic medications, and lower insertion costs (Moureau et al., 2015).

In both hospitals, vascular access nurse teams were comprised of former procedure area nurses and emergency department nurses who participated in training to assess and evaluate patients' long-term access and care needs. The team ensured that all patients had safe access even under difficult circumstances and achieved certification in vascular access specialty for all clinicians. Team members educated bedside nurses and physicians to promote MC understanding and use and rounded on patients with MCs daily to assess access site, dressing, and provide education or intervention when needed (Moureau et al., 2015).

The authors note that CVADs in general, without complications, are far costlier than MCs and place patients at higher risk for serious complications (Moureau et al., 2015). MC program implementation is not without difficulty as noted by the authors, insertion techniques can be challenging initially and each hospital made adjustments to support users and MC insertion success (Moureau et al., 2015). This study was limited by small sample size and narrow complication reporting focusing on CLABSI alone. The participant self-report method limited this study, as recall bias could threaten internal validity.

In a study conducted by Xu et al. (2016) researchers aimed to compare the utilization and safety of PICCs compared to MCs. This retrospective study was performed at a large academic medical center. This facility utilized vascular access nurse teams to place PICCs and MCs. The study sample included 200 MCs and 206 PICCs placed throughout varying inpatient care areas of the facility. Researchers used the electronic health record to collect length of stay, VAD dwell time, complications, comorbidity score, demographics, and insertion site (Xu et al., 2016).

Complications were defined as CLABSI, occluded line resulting in discontinuation, VAD leaking, pain, edema, or catheter fracture. Serious complications were defined as infiltration, phlebitis, or infection resulting in discontinuation of line, DVT, positive blood culture, or readmission because of issue related to line. PICC line infections were defined using the CDC criteria (CDC, 2019) and MC infections by positive blood culture or gross site infection. Analysis of data was performed using the SAS 9.3 statistical package, the Kruskal-Wallis test to explore differences between

groups, and Fisher exact test to explain strength of association for categorical variables (Xu et al., 2016).

From a total of 367 patients, 172 had a MC only, 185 had a PICC only, and 10 had both a PICC and MC during the same single admission (Xu et al., 2016). Findings included 12 total complications associated with PICCs, 10 were serious complications including phlebitis, infection, DVT, and positive culture requiring readmission and two were not considered serious and related to nonpatency. MCs were associated with a total of 39 complications, 18 were serious including phlebitis, infection, DVT, positive culture, and infiltration, and 23 were not considered serious including nonpatency, pain, leaking, and edema. The difference in severe complications between two groups was not statistically significant, but MCs were associated with more complications overall. Complications from MCs did not cause any readmissions and 4 readmissions were caused by PICC complications (Xu et al., 2016).

Researchers analyzed readmission rates and complications classified by comorbidity score and ICU placement in an attempt to eliminate patient confounders (Xu et al., 2016). After analysis, researchers found that minor complications in all hospital areas and readmissions, regardless of comorbidity score, were still more likely to be associated with MCs than PICCs. None of the 5 positive blood cultures in MC patients were thought to be associated with MCs and 2 of the 5 positive blood cultures in PICC patients were reported as CLABSIs. PICCs had a median duration of 12 days and MCs 5 days. The authors acknowledge a growing concern of administering vesicants, especially vancomycin, into MCs. Thirty-one participants received vancomycin and 3 developed phlebitis (Xu et al., 2016).

The authors acknowledge that the retrospective design at a single facility during a short study duration period and with only one CVAD manufacturer limits the study. The researchers included inpatient complications only, which could have resulted in a significant amount of missing complications for the PICC group, as 103 PICC patients were discharged with their lines in place while only 3 MC patients kept their line after hospital discharge (Xu et al., 2016). Although the study network is the largest in the area, the research was unable to capture readmission to another network facility and could have missed complications causing readmission. This can be assumed to be equal among groups and does not threaten internal validity. The data was not presented as complication per 1,000 catheter days which could have provided a more clear comparison of the two groups. Complication rates could only have been measured if they were documented correctly in the electronic medical record. Errors in documentation can be assumed to occur equally throughout groups and therefore do not threaten internal validity (Xu et al., 2016). The authors conclude that MCs are an acceptable alternative to PICCs to reduce CLABSI rates, even with the increased potential for mild complications. The authors encouraged facilities to report IV access utilization data including patient selection criteria to increase comparable data (Xu et al., 2016).

Vesicant Administration through MC

A study by Caparas and Hung (2017) aimed to determine the safety and effectiveness of administration of vancomycin via MCs. Researchers conducted a retrospective chart review of 10,078 patients with MCs from June 2011 to June 2016 to determine if vancomycin was administered. The authors found 1,086 patients to have received vancomycin and charts were further examined for documentation of

complications including infiltration, DVT, CLABSI, and phlebitis. Complications were defined appropriately for data collection standardization. All MCs were placed and maintained according to current best practice guidelines. Vancomycin was diluted routinely to 4mg/mL and administered at recommended rates (Caparas & Hung, 2017).

The average age of participants was 73.6 years with 47% of patients being female and 53% male. Almost all patients received at least one additional antibiotic medication and other IV medications via a MC. Vancomycin doses ranged from 0.5-1 gram administered once or twice per day and 45% of patients received vancomycin for less than 6 days duration, 55% for 7-14 days, and 5% for 15-25 days with an average of 7.5 days (Caparas & Hung, 2017). Every MC was placed in a deep vein of the upper arm, except for two lines that were placed mid forearm.

Researchers found phlebitis documented in six patient records, all instances occurred before day 14 of vancomycin administration. Infiltrations were found in 13 patients, none of which appeared to be serious or requiring additional treatment. Leaking was documented in 10 patient charts, none of which were found to have DVT, and authors noted that the manufacturer later made changes to line design to prevent leaking. No patients were found to have a blood stream infection related to the MC. Ten patients had MC removed for an undocumented reason and those patients did not have documented DVTs (Caparas & Hung, 2017).

Researchers conclude that complications occurred overall in 2.7% of patients studied with no serious complications including DVTs or blood stream infections. The authors determined their phlebitis findings to be considerably lower than what would have been expected, given the pH restrictions placed on MCs. Findings conclude that

when correctly diluted to 4mg/mL and administered through a MC, vancomycin is not associated with tissue destruction with accidental infiltration and is, therefore, not a vesicant (Caparas & Hung, 2017).

The authors go on to predict the potential outcomes and impact on each of these patients had a PICC been placed for vancomycin administration. Using the lowest complication rate in reported data for PICC utilization, it is predicted that approximately 16 patients would have developed a CLABSI and one or two may have died as a result (Caparas & Hung, 2017). The authors determine a significant cost savings by avoiding CLABSI treatment and using MCs saves about \$90 per line.

Limitations described by the authors include the retrospective study design, and suggested a randomized trial comparing PICCs to MCs would be ideal. Because grading scales for infiltration and phlebitis are not typically used at this facility, the researchers counted any indication of these complications as a positive finding which could have resulted in an overestimate of findings. This does not impact internal validity as this would only result in a bias toward the null hypothesis. Relying on clinical documentation alone limits this study as some complications may not have been documented appropriately, for example 10 cases were missing documentation of reasons for line discontinuation in which potential complications are unknown (Caparas & Hung, 2017).

VAD Appropriateness Criteria

Given the research demonstrating inappropriate and overuse of PICCs, Chopra et al. (2015) organized a multidisciplinary team of experts to develop appropriateness criteria for the care and management of VADs in hospitalized patients. The team aimed to develop a list of indications for PICC placement, define appropriate practice for

insertion and care of PICCs, determine practices for prevention and treatment of PICC complications, and rate appropriateness of PIV placement for situations in which a PICC was placed.

The authors utilized the RAND Corporation/University of California Los Angeles (RAND/UCLA) Appropriateness Method (Fitch et al., 2001) to develop appropriateness criteria for PICC use (Chopra et al., 2015). The RAND/UCLA method, used to measure overuse of medical procedures, establishes a procedure as appropriate when the expected health benefits of the procedure exceed the negative consequences significantly enough that the procedure is worth performing, regardless of cost. This method allowed authors to synthesize evidence along with consideration of expert practice insights to ensure that recommendations will be evidence-based and relevant to practice. Because available evidence on this topic is provided from research conducted in a variety of specialties, populations, and study designs, the findings can be misinterpreted and lead to disagreements between experts on appropriateness rating for an individual scenario. The RAND/UCLA method simply calls for minimizing these disagreements when making a decision, rather than achieving consensus. The RAND/UCLA method produces results with high internal validity due to clear definitions and instructions with a systematic and reproducible rating system (Fitch et al., 2001).

The panel systematically performed the following steps of the RAND/UCLA method to develop the appropriateness criteria. The first step, information synthesis, involved systematically reviewing and synthesizing the literature after search of English-language articles from November 2012 to July 2013 in appropriate databases and excluded articles specific to pediatrics or lines that are not comparable to PICCs.

Guidelines relevant to the research were included in the literature synthesis. All articles were reviewed for eligibility by two authors and disagreements resolved by consensus. The second step involved panelist selection in which national and international experts representing a variety of areas including vascular access, medicine, surgery, infectious disease, critical care, pharmacy, interventional radiology, nephrology, and hematology/oncology were invited to participate on the panel with a final recruitment of 15 panelists. A patient with experience related to VADs participated on the panel, but did not rate scenarios (Chopra et al., 2015).

The third step, creation of scenarios, the authors developed clinical scenarios based on article findings that were used to rate appropriateness of insertion and maintenance of PICCs. The authors compared other VADs including PIVs, MCs, ports, and CICC with PICCs to determine accuracy of clinical decision making around line selection. The scenarios were developed to prompt judgment of realistic clinical situations and each panelist was asked to provide a list of relevant concerns with PICC use to increase validity of this work. A conceptual framework was developed and indication for PICC insertion was categorized into duration of access, type of infusate, and use for particular reason. Each clinical scenario incorporated patient specific factors including cancer or critical illness, device-specific factors including gauge and number of lumens, and provider-specific factors including technique of insertion or provider inserting the line. Scenarios related to the use of PIVs and appropriate management of PICC complications were also included. All scenarios were pilot-tested with two physicians and feedback was used to make edits for clarity. A total of 665 scenarios and 391 indications for PICCs were developed (Chopra et al., 2015).

The forth step, rating of scenarios and indications, began with each panelist reviewing the scenarios without consideration to cost or availability of resources. Each scenario was rated on a scale of 1 to 9 with 1 indicating harm outweighs benefit and 9 indicating benefit outweighs harm. A rating of 5 indicates harm and benefits are equal, or the panelist could not make a judgment. A rating of 1 to 3 or 7 to 9 indicated preference of one device over another and ratings of 4-6 indicated no preference. Each scenario was rated twice by each panelist, the first round involved individual rating and the second rating was conducted in person with a scientific content expert and methodology expert moderating a panel discussion of all scenarios and indications. Round two encouraged discussion of scenarios in which ratings were in disagreement or neutral. The final step, data processing and analysis, classified indications into three categories including appropriate with a median score of 7 to 9, uncertain/neutral with a median score of 4 to 6, and inappropriate with a median score of 1 to 3. Disagreements, not determined to be appropriate or inappropriate, were defined as at least 5 of the panelists rating an indication as appropriate and at least 5 rating the same indication as inappropriate (Chopra et al., 2015).

Recommendations from panelists are provided based on situation (Chopra et al., 2015). For hospitalized medical patients receiving an infusion of peripherally compatible infusates, line appropriateness is based on expected duration of infusions. For a duration of 5 days or fewer a PICC was rated inappropriate, for a duration of 6 to 14 days a PICC was rated appropriate, but preference for MC or USGPIV was indicated as the preferred VAD. Panelists preferred PICCs to MCs for a duration longer than 15 days but recognize that MCs may be used for up to 4 weeks. For administration of vesicants

including total parenteral nutrition (TPN) and chemotherapy that are not compatible with peripheral administration, PICC is appropriate for all durations. Panelists could not agree on placement of PICCs for frequent blood samples or difficult venous access for duration of use less than 5 days. After panelist discussion, recommendations include considerations on an individual basis with discussion between patient and provider about options, risks, and benefits (Chopra et al., 2015).

For patients with chronic kidney disease (CKD) stages 1 to 3a, PICC recommendations should align with those of standard hospitalized patients, but panelists acknowledge other individual CKD patient factors including blood pressure, age, race, and magnitude of albuminuria that may impact progression of renal disease and ultimately recommend consultation with nephrology before considering PICC insertion if severity of underlying kidney disease is indefinite. The panelists rate PICCs and MCs as inappropriate for stage 3b CKD patients and stress the importance of preserving peripheral and central veins for potential hemodialysis and creation of arteriovenous fistulae and grafts for these patients. The panelists again recognize the need to address individual patient situations including urgency of venous access need and availability of resources. For cancer patients when considering the increased risk for thrombosis and consequences of infection, PICCs were rated as appropriate only if the duration of treatment was three months or fewer (Chopra et al., 2015).

For critically ill patients, PICCs were rated as inappropriate for less than 15 days of infusing peripherally compatible medications (Chopra et al., 2015). PIVs were rated as appropriate for fewer than 5 days and MCs appropriate for durations of 6 to 14 days of in this population. PICCs were rated as appropriate for hemodynamically unstable patients

when central access or hemodynamic monitoring was required. CICC's were preferred to PICC's for urgent situations. Panelists rated PICC's as appropriate for palliative treatment during end-of-life care. Panelist recommendations for appropriate PICC practices include consulting relevant specialists as needed for guidance before ordering a PICC. Single-lumen PICC's of the smallest gauge are recommended unless indication for multi-lumen PICC placement is met (Chopra et al., 2015).

Appropriate PIV practice recommendations include the use of ultrasound guidance for placement of PIVs in patients with difficult venous access with duration of treatment of 5 days or less. Remove PIVs when swelling, redness, or phlebitis is present at insertion site. PIVs should not be removed, regardless if line was placed outside of the hospital, on a routine schedule and should only be rotated when clinically indicated by insertion site complications. Routine placement of PIVs without clinical indication is inappropriate (Chopra et al., 2015).

The authors combined existing evidence with expert review to develop appropriate indications for use of VADs to decrease inappropriate placement and risk of preventable complications in hospitalized patients. The guidelines provided offer patient-specific considerations to help clinicians make the most appropriate decisions in complex patient situations. The authors recognize the challenges clinicians may still encounter with VAD selection as it is difficult to predict duration of treatment and time constraints may limit ability to fully consider options and weigh risks and benefits. The study is limited by the exclusion of neonatal and pediatric studies when developing recommendations, but the authors recognize the need for similar work for these populations. The study panel did not include bedside nurses, but vascular access nurses

were represented. Applicability of these recommendations may vary by organization and provider given available resources, competency, and education (Chopra et al., 2015).

Vascular Access Nurse Teams

The relatively new specialty of vascular access nursing is comprised of nurses who are trained to specialize in insertion, maintenance, and monitoring of vascular access in hospitals. Chopra et al. (2016) surveyed vascular access nurses across 47 Michigan hospitals to explore their knowledge, beliefs, practice, and experience related to PICC utilization and management. The web-based survey was administered to purposeful sample of vascular access nurses. The survey instrument, PICC1, was developed by the researchers through a literature review of evidence-based guidelines and studies pertaining to vascular access nurses' practice. Leaders in vascular access nursing provided consultation to ensure validity of the questions. The survey was pilot tested with nurses outside of the sample group and refined based on feedback and tested again by members of the research team. The survey collected basic demographic data and assessed nursing background, practices, types of devices used, technologies used, management of complications, and relationships with providers (Chopra et al., 2016).

The survey received 140 responses, an 81% response rate, with 95% of respondents reporting that they place the majority of PICCs at their hospital, 23% reported holding a vascular access certification (Chopra et al., 2016). Ninety-five percent of respondents reported that their hospital had written policies for standard care of PICCs, and 30% reported having policies regarding the appropriateness or necessity of PICCs. Participants reported the most common indications for PICC use as intravenous antibiotics at discharge, difficult venous access, and chemotherapy. Forty-six percent of

participants reported placing a PICC in a patient receiving dialysis, but 91% reported receiving approval from nephrology before device placement. Ninety-eight percent of respondents reported that they were not able to remove unnecessary PICCs without physician approval. Two-thirds of vascular access nurses surveyed reported relationships with bedside nurses and providers to be very good or good. Fifty-one percent of respondents described leadership support as excellent, very good, or good while 43% perceived leadership as fair or poor (Chopra et al., 2016).

Researchers found that indications for PICC placement aligned with evidence-based indications in the literature, but the frequency of use in dialysis patients was surprisingly high given the recommendations to avoid use of PICCs in these patients (Chopra et al., 2016). The researchers found variations in placement and management of PICCs that indicates a need for disseminating relevant literature to promote consistent practice. Results demonstrated that a large portion of vascular access nurses felt that some PICCs were unnecessary and were placed without appropriate clinical indication. Reported positive relationships with bedside nurses and providers indicates that interventions to improve care involving collaboration with these partners could be highly effective. The researchers acknowledge a limitation in the survey sample as all respondents are employed at hospitals that are engaged in improving PICC practices, indicating that this group may be disproportionately motivated in this area and is not necessarily representative of all vascular access nurses (Chopra et al., 2016).

Chopra et al. (2017) distributed the web-based survey, PICC1, to vascular access nurse specialists, to members of the Infusion Nurses Society and the Association for Vascular Access to assess training, experiences, and practices of these specialists. A total

of 1698 vascular access nurses completed the survey with representatives from all 50 US states and 4% practicing outside of the US. Eighty-three percent of respondents reported that vascular access nurses were responsible for placing most of the PICCs at their facility and 76% of all participants worked in inpatient settings. Most participants, 92%, reported that PICC placement rates are tracked at their facility, but only 61% reported that dwell times of PICCs are monitored. Almost all participants reported that their facility had policies regarding PICC insertion and care, however only 63% had a policy to review necessity of PICCs that are in place. For participants at facilities with necessity review policies, 45% reported this review was performed by the bedside nurse, 32% by the providers, 32% by a multidisciplinary approach, and 23% by vascular access nurses on daily rounds. Twenty-three percent reported that vascular access nurses could remove an unnecessary PICC without provider approval (Chopra et al., 2017).

The most common indication for PICC placement reported was antibiotic treatment after discharge followed by difficult venous access and administration of total parenteral nutrition (Chopra et al., 2017). Fifty-eight percent of participants reported placing PICCs in dialysis patients, but 91% stated they received approval from a nephrologist before placement. Forty-two percent of vascular access nurses surveyed reported that more than 10% of PICCs placed at their facility were inappropriate or avoidable. Relationships with providers were reported as *good or very good* by 73% of respondents and 78% reported *good or very good* relationships with bedside nurses. Support from facility leadership was reported as *good or very good* by 36% and *poor or fair* by 36% of vascular access nurses (Chopra et al., 2017).

Survey results demonstrate variation in vascular access nurses' perception of appropriateness of PICC placement as well as support of leadership at their facilities (Chopra et al., 2017). The authors hypothesize that variation in practice among these specialists is likely related to the limited high-quality evidence and best practice recommendations available to guide practice. Implementation of MAGIC guidelines is recommended to ensure the latest evidence and expert opinion is utilized to address best practices for the use of PICCs and other VADs in a variety of patient scenarios. It is likely that many vascular access nurses have not yet incorporated the latest evidence into practice, which highlights the need to additional training, education, and certification in this specialty. The authors acknowledge the limitations of the convenience sample including selection bias and nonresponse to the survey (Chopra et al., 2017).

Role of Vascular Access Nurse Teams

Krein et al. (2017) conducted web-based surveys to explore the function of vascular access nurses in a healthcare team, the perceived role of nurses in this specialty, and how their practice could relate to appropriateness of PICC use in hospitals. The 76-question survey was developed by the study team and pilot tested by several nurses before distribution by e-mail to all 8300 members of both the Association for Vascular Access and the Infusion Nursing Society. The survey focused on vascular access nurses' relationships with bedside nurses and providers, hospital policy and practices regarding PICC use, and their perceived role as specialists bringing value to practice. The final sample size of 1147 vascular access nurses resulted from excluding respondents who did not identify as vascular access nurses and those who practiced outside of a hospital (Krein et al., 2017).

Results indicated great variability in the perceived role of vascular access nurses in relation to PICC use in hospitals (Krein et al., 2017). Perceived function in their role varied greatly between functioning as operators, simply performing the technical function of line placement, to specialized consultant roles, providing expert recommendations. Among those who viewed their role as specialized consultants, perceived variations in the value of their recommendation among providers and bedside nurses emerged. Vascular access nurses who felt that they are valued consultants reported better relationships with other members of the care team than unvalued consultants and operators (Krein et al., 2017).

Valued consultants reported higher rates of safety practices with PICCs at their facilities, including tracking PICC placement and dwell time data and lower rates of inappropriate use of PICCs and inappropriate device removal. Hospitals with vascular access nurses who perceive their role to be consultants with value-added contributions to decision making have a lower frequency of inappropriate PICC use. Vascular access nurses who felt they were valued consultants had more experience in practice and placing PICCs than the other two role groups (Krein et al., 2017).

Survey findings demonstrated, in U.S. hospitals, the majority of PICCs are placed by vascular access nurses (Krein et al., 2017). Results from the research indicate that understanding how to promote interprofessional collaboration is critical to ensuring improved appropriateness of PICC use in hospitals with vascular access teams. Further research is needed to understand the association between the perceived role of the vascular access nurse and device utilization practices. Selection bias is a potential threat to findings given the sampling process. There is potential for response bias as all findings

are based on self-report from nurses and question interpretation could be a factor. There may not be an association between perceived role and appropriate PICC use as more satisfied nurses may be more likely to report more favorable practices (Krein et al., 2017).

Overall, findings suggest that vascular access nurses' perceived role influences PICC use in hospitals and improved interprofessional collaboration improves PICC utilization. An environment that allows for vascular access nurses to use their expertise in the specialty to make valued recommendations for line selection is a necessary component in improving PICC use (Krein et al., 2017).

Healthy Work Environment

The American Association of Critical Care Nurses Standards for Establishing and Sustaining Healthy Work Environments (2016) were developed in response to evidence correlating unhealthy health care work environments to stress for health care professionals, specifically nurses. Unmanaged stress in an organization lacking support for professionals can lead to medical errors and ineffective care delivery. The AACN maintains that the six essential standards, skilled communication, true collaboration, effective decision making, appropriate staffing, meaningful recognition, and authentic leadership, must be in place to ensure a healthy work environment exists that will support professionals to deliver high-quality, safe patient care (AACN, 2016).

According to the AACN (2016), skilled communication is as important for successful nursing practice as clinical skills. Skilled communication involves a dialogue among interprofessional team members that promotes collaborative thinking and decision-making. Effective communication supports mutual respect among team

members and supports finding solutions and achieving shared goals (AACN, 2016). True collaboration is an ongoing practice among teams who understand and embrace the strengths and expertise of professionals on the team. The complex needs of patients and families cannot be adequately met without true collaboration in which each discipline is sharing knowledge and working together toward the common, patient-centered, goal (AACN, 2016).

As advocates for the best interests of patients and families, nurses must be equal partners with other members of the interdisciplinary team to facilitate effective decision-making. Nurses must work to close the autonomy-accountability gap to maximize their contribution to care discussions and decisions (AACN, 2016). Appropriate staffing ratios that address varying patient needs and nurse specialty knowledge and expertise are important to high-quality care delivery within a healthy work environment (AACN, 2016). As a valued member of the interprofessional team, nurses must be recognized for their unique commitment to patient care. A healthy work environment cannot exist without a culture of meaningful recognition that acknowledges the contribution of each member of a diverse team (AACN, 2016).

To develop and maintain a healthy work environment, nurse leaders must engage team members in the process and fully embrace the culture (AACN, 2016). The AACN supports the need for qualified nurse leaders prepared as change agents, team builders, and role models for collaboration to create this environment in a health care organization. The leader must be innovative and understand that sustained success of a healthy work environment involves support for ongoing education and coaching of team members to develop interprofessional collaboration skills (AACN, 2016).

Interprofessional collaboration is best supported by health care organizations that evaluate team member accountability and address willingness to collaborate appropriately, with an emphasis on incorporating the decision-making authority of nurses (AACN, 2016). Nursing leadership, in an organization committed to delivering the highest quality patient care, will support clinical nurses as professionals and encourage participation in education and coaching opportunities that will further develop the collaboration skills necessary to maximize efforts of the interprofessional team (AACN, 2016). These standards support the need for a healthy work environment to promote high quality care in response to the variety of challenges facing healthcare professionals in the increasingly complex and rapidly changing environment in which care is provided (AACN, 2016).

Clinical Decision Support

Increasing the availability of evidence-based support tools at the point of care to allow clinicians align care decisions with evidence can enhance quality of care and decrease health care costs (Nelson & Staggers, 2018). Using an informatics-based tool to redesign the methods in which care is provided can close the gap between evidence and practice. When considering the large amount of research conducted in health care every year, it is evident that most clinicians would find it nearly impossible to read all relevant research published on a variety of necessary topics and translate findings into applicable practice recommendations. If a clinician should select the best plan of care that will be most effective for a patient, their decision should be supported by all best available evidence (Nelson & Staggers, 2018).

Clinical decision support (CDS) systems, described in research provided on the Agency for Healthcare Research and Quality (AHRQ) Health Care Innovations Exchange, use automation and informatics-based tools to bring evidence to the point of care for clinicians (Berner, 2009). CDS incorporates patient-specific information from the electronic medical record with clinical guidelines and best evidence to provide clinicians with pertinent information to make clinical decisions for patients that are aligned with the most recent pertinent findings.

According to the AHRQ Health Care Innovations Exchange, CDS systems have the ability to improve quality of care in many ways including preventing dangerous drug interactions, improving appropriateness of antibiotic therapy choice, and increasing use of recommended therapies for treatment of chronic conditions (Berner, 2009). There are many factors that enhance or disrupt the impact and effectiveness of the CDS system including timing of reminders, delivery of information, and user control over CDS recommendations. A needs assessment, purchasing plan, design plan, implementation process, and evaluation plan must be performed before a CDS system can be incorporated into a workflow process. A CDS system must be maintained and evaluated through data collection to understand the impact on care and identify potential areas for improvement. To achieve optimal outcomes with CDS system use, the tool must be specifically designed to meet the needs of the patients and users to improve quality of care and efficiency (Berner, 2009).

CDS can improve safety and quality of care by bringing the highest level of evidence available directly to clinicians to support clinical decision making in practice (Berner, 2009). When implemented and utilized appropriately, CDS can be used by

clinicians to apply the evidence-based knowledge to a unique patient scenario to provide clinical suggestions for considerations by the clinician. Knowledge-based CDS can assist clinicians to apply clinical guidelines to patient specific data to suggest best practices. CDS applications typically involve the use of technology-based systems that allow for combining knowledge with necessary patient specific information to produce a meaningful recommendation to the clinician to support decision making (Berner, 2009).

CDS systems can impact clinical decisions in a variety of ways and through different approaches. User control and autonomy of decision making when using these systems can range from automatic notifications that clinicians can determine to ignore or follow to systems that are accessed by demand from the user when needed. CDS systems are most successful when users are able to easily access these resources with minimal disruption to workflow processes (Berner, 2009). User willingness and motivation to use CDS systems are crucial to integrating these processes. Implementation of new CDS systems, which alter routine practice, can create resistance among users especially if clinicians perceive the CDS system to limit desired autonomy and require additional time to use (Berner, 2009).

Research by Cortez, Dietrich, and Wells (2016) performed a cluster randomized trial to test a new CDS system integrated into the nursing electronic documentation software and determine the impact on an evidence-based nursing intervention. The CDS offered evidence-based information to nurses in drop-down boxes available during decision making processes. The researchers evenly divided four adult oncology clinic sites into two groups, one control without CDS group and one intervention with CDS group. Researchers measured the outcome of documentation of the evidence-based

intervention. A symptom documented by a nurse in the intervention group prompts the nurse to have a conversation with the patient, noting the evidence-based intervention for that symptom (Cortez et al., 2016).

A statistically significant effect was demonstrated, comparing the rate of evidence-based nursing intervention after education session. This increase in evidence-based intervention rate did not sustain in either group, demonstrating that the CDS itself had no positive effect on the intervention rate (Cortez et al., 2016). The authors concluded that CDS implementation designed to increase evidence-based practice among nurses requires support strategies, like audit and feedback, to be successful. The authors also note the distinction of evidence-based documentation practices between nurses and physicians. Medical research related to CDS implementation with outcome measures involving evidence-based practice documentation may be more successful with physicians as this type of documentation is often tied to reimbursement and communication among the care team for physicians. Nurses may not perceive their documentation as valuable to the care team communication and it is not tied to reimbursement, so these motivating factors for documentation are not present. Lack of perceived value in documentation may have resulted in intervention practices that were not captured simply because they were not documented (Cortez et al., 2016).

Utilizing MAGIC to Guide Practice

Swaminathan et al. (2018) utilized the MAGIC evidence-based guideline to determine if utilizing decision-making criteria can improve appropriateness of PICC use and decrease complications associated with CVADs in hospitalized patients. The intervention site was a 600-bed community teaching hospital that was collected data on

patients with PICCs. The sample included all adult patients admitted to an ICU or general care unit who received a PICC for any reason. Trained abstractors retrieved data from the medical records of subjects beginning at PICC placement and ending at PICC removal, death, or when 70 days of data collection had been reached. Data collected included patient characteristics, appropriateness measures, device-related complications, number of PICCs including number of lumens, number of MCs, and patient days. Data was collected for one year pre-intervention and one year post-intervention (Swaminathan et al., 2018).

The MAGIC-based intervention included a tool to evaluate appropriateness of PICC placement before insertion, nurse training on MAGIC recommendations, electronic medical record changes to incorporate the recommendations, and provider education pertaining to the MAGIC recommendations. The vascular access nurse team used a standardized method to evaluate each PICC order for appropriateness based on the MAGIC criteria. The team determined if the PICC order was appropriate based on indication, proposed duration, and the nature of the infusate to be administered. If determined to be appropriate, the PICC was placed as ordered, if inappropriate the team discussed alternative device options with the ordering provider (Swaminathan et al., 2018).

The vascular access nurses were provided with a 4-hour education session that involved ultrasound training and education regarding peripheral alternatives to PICCs. A collaborative team established changes to the electronic medical record that allowed pharmacists to highlight infusate orders that required central lines or multiple lumens.

Nine peer hospitals were utilized as an external control to account for trends in vascular access device selection (Swaminathan et al., 2018).

Results of the study found PICC use decreased significantly and MC use increased after MAGIC implementation (Swaminathan et al., 2018). Multi-lumen PICC use decreased after implementation and single-lumen PICC use increased. The researchers found a significant decrease in inappropriate PICC use at the study site, but a smaller, yet significant, decrease in inappropriate PICC use was found at the control sites. The greatest impact on PICC use was demonstrated in the categories of PICC use for less than 5 days and PICC use for less than 14 days in the ICU. The rate of serious complications, included DVT and CLABSI, did not decrease significantly when compared to the control sites, but this could be contributed to overall low rate of these complications. The authors were able to conclude that implementation of MAGIC criteria led to a modest improvement in PICC use as a small, but significant, improvement was seen when compared to the control sites (Swaminathan et al., 2018).

The authors note a significant cost associated with conducting this study and a reasonable return on investment. Recommendations for future quality improvement initiatives of this kind include careful consideration to cost-benefit ratio. The authors acknowledge limitations to this research including the single study site and which limits generalizability. The study methodology included multiple pieces, making it difficult to determine which part of the intervention, if any, was most impactful. Knowing the most impactful intervention could guide future research and quality improvement initiatives in this area (Swaminathan et al., 2018).

Theoretical Framework

Lewin's Change Theory and the Synergy Model for Patient Care are the theoretical models used to guide this quality improvement project.

Lewin's Change Theory

A social psychologist of the 20th century, Kurt Lewin, developed the force field analysis as a framework for examining the factors that influence a situation. In this theory, a field is seen as a system, which must be completely explored after a change is made to determine its effect. A force's balance is disrupted during change. A force field analysis establishes two forces, the driving forces that encourage movement to a new goal and restraining forces that impede progress toward the outcome. Force field analysis framework forms the foundation of Lewin's 3-stage theory of planned change (McEwen & Wills, 2011). For planned change to be effective, driving forces should be identified and emphasized and restraining forces should be minimized. Effective change is described by Lewin as a return to equilibrium resulting from a balance of forces. Identification of these forces could predict when change will be effective (McEwen & Wills, 2011).

The first stage, unfreezing, involves preparing for change. This stage includes a change agent identifying a problem and a need for change and then informing others of the need for change. The change agent needs to emphasize the necessity of the change and choose a solution to prepare for the next phase. For planned change to be effective, driving forces should be identified and emphasized and restraining forces should be minimized (Lewin, 1951).

The second stage, movement, involves examining change as a process and recognizing individuals moving to a new way of being. Change, especially in healthcare, can cause feelings of uncertainty and stress in individuals involved, so individuals need encouragement to try out the change (McEwen & Wills, 2011). The change agent should move through the change process gradually and thoughtfully, recognizing that change does not happen quickly. For successful change, resistance should be anticipated. During this phase driving forces should exceed restraining forces. Coaching and guidance during this, often challenging, phase is required to move individuals to the revised process (Lewin, 1951).

The third stage, refreezing, requires stabilization of the change so that it can sustain. The change agent must neutralize restraining forces that are hindering change and emphasize driving forces to continue to stimulate change. If the change is successfully fixed into practice, equilibrium is restored, and the change is effective and will continue as the new standard (McEwen & Wills, 2011). In introducing a new evidence-based guideline, nurses' perceived usefulness of the guide is motivation for the sustained success of this tool in practice.

Lewin's theory of planned change considers the process of prepared change and when the described 3-stage process is used correctly, effective change is achieved. This theory is best utilized in stable environments when there is adequate time to create change. Although this theory is one of the oldest in change management, it is efficient and easy to use and understand. These qualities allow this theory to be used often in healthcare, especially in nursing administration and education, and is considered to be

most effective when a top-down approach, in which senior leaders drive change is used (McEwen & Wills, 2011).

The Synergy Model for Patient Care

The American Association of Critical-Care Nurses (AACN) developed the Synergy Model for Patient Care in the early 1990s to describe nursing practice, especially the unique contribution of critical care nurses. The goal of this model development was to describe the distinct skills that nurses bring to patient care while meeting the needs of patients and families (Hardin, 2013). This conceptual framework emphasizes nurse competencies that are driven by patient characteristics. The underlying concept of this model explains that optimal patient outcomes are more likely to occur when patient characteristics and nurse competencies are in synergy (Curley, 2007).

The Synergy Model recognizes the unique characteristics that each patient and family bring to a clinical scenario. These eight characteristics include stability, complexity, predictability, resiliency, vulnerability, participation in decision making, participation in care, and resource availability (Hardin, 2013). This model established eight nurse competencies including advocacy, clinical judgment, caring practices, collaboration, response to diversity, systems thinking, clinical inquiry, and facilitator of learning to explain nursing practice (Hardin, 2013). The characteristics for nurses and patients are ranked on a five-point Likert scale with 1 representing the novice nurse to 5 ranking expert level and 1 representing the worst patient situation to 5 as the most ideal, respectively. The patient characteristics describe what is consistently observed in the acute and critically ill patient population and the nurse characteristics are considered competencies required for caring for the described patients (Hardin, 2013). This model

explains how the complex integration of skills, knowledge, and attitude by nurses meets the unique needs of patients to maximize patient outcomes (Curley, 2007).

The Synergy Model describes nursing practice in caring for acute and critically ill patients in a hospital setting. This model is clear and easy to understand because the language used is consistent with terms common to healthcare settings. The patient and nurse characteristics are appropriately described so that any healthcare professional with basic knowledge of care for acutely ill patients can understand and apply this theory. The model displays a consistent approach to nurse and patient characteristics with equivalent scales and similar terms used to explain all components (Smith, 2013).

The Synergy Model is unique in that it was created for a specific nursing specialty, critical care, and was developed by a group of specialists from the nursing profession (Smith, 2013). Development of this model is logical, as its foundation simply states that when a nurses' skills and experience meet the unique needs of a patient and family, the patient will benefit from optimal outcomes (Stewart, 2018). The AACN developed this model in an attempt to explain how the complex art of nursing is more convoluted than the often-perceived practical actions of following a standard order set developed through a medical model (Hardin, 2013). This broad conceptual model explains how connecting patients with nurses that are best equipped to meet their unique needs will create a synergistic effect, meaning better patient outcomes are likely. The Synergy Model is not specifically predictive of outcomes and remains general in its assumptions (Smith, 2013).

The Synergy Model has an obvious focus on the important relationship between patients and nurses. The authors of this model believe the reciprocal nature of the nurse-

patient connection is unique and enhances the contributions made by the nurse to care (Hardin, 2013). The 16 characteristics described are simple and straightforward to guide readers to utilize this model and create optimal nurse-patient relationships. The underlying concept of this model is especially simple, as nurses with specific skills and attitudes matched with the unique characteristics of patients will likely result in optimal patient outcomes. This model correlates closely with clinical nursing practice in both acute and critical care settings (Smith, 2013).

The AACN Synergy model has shown to be broad and applicable to many other settings as well. The model has been utilized in outpatient settings, specifically to understand and manage the complexities of outpatient congestive heart failure patients (Smith, 2013). This model may have been developed specifically for nurse-patient relationships in critical care, but characteristics could be applicable to other disciplines. The nurse characteristics described may not be unique to nurses as many other healthcare professionals use these skills in patient care, but the complex utilization of all 8 characteristics driven by a patients' individual state is likely unique to nursing alone (Smith, 2013).

The Synergy Model has been utilized across critical care areas in a variety of ways, defining requisite of nurse skills to guiding preceptor programs for new nurses. In addition, this broad framework has been utilized to develop acuity tools for medical-surgical units and to support development of a staffing tool to ensure safe transport of patients between hospitals (Stewart, 2018). The Synergy Model is easy utilized frequently in research and education in describing phenomenon unique to nursing practice.

The Synergy Model is consistently useful across nursing roles and settings. From acuity tools developed from this model used by a clinical charge nurse making an appropriate patient care assignment to a critical care nurse educator using this model to develop a preceptor program for new nurses. The clear explanation of concepts in the model make it ideal for bedside nurse implementation. The models' explanation of nursing complexities overall creates an ideal situation for use as a framework for practice development by nursing leadership (Smith, 2013). This model appears to be broader than many other middle range theories as it addresses all major concepts of nursing, although the model was originally developed to be limited to acute and critical care inpatient nursing. The model appears to be narrow as it is easily applicable to practice, but the successful use of this model beyond the hospital has shown it to have a larger scope than initially intended (Smith, 2013).

Through introduction of a new evidence-based guideline to drive nursing practice, this project uncovers unanticipated complexities of nursing practice that impact the vascular access nurses' utilization of this guide. Although the MAGIC guideline may appear straightforward and easily applicable to any acute care patient, the unique complexities of the patient-nurse relationship may impact use of the guidelines in practice. The AACN Synergy Model and Lewin's Theory of Change will be utilized to understand and articulate barriers to guideline utilization as a standard across all acute care patients. This project unleashes understanding into the complexity that is nursing care in terms of standard guideline use for acute care patients.

Project Objectives

The proposed project objectives included implementing an evidence-based decision support tool for use by the vascular access nurse team to improve appropriateness of VAD selection for hospitalized adult patients at a large academic medical center. Decision support guidelines were composed of evidence-based recommendations from available MAGIC resources (Appendix A-D). The algorithms implemented address complex patient scenarios that challenge clinicians, specifically vascular access nurses, when determining the most appropriate VAD for a patient.

Project goals included improving appropriateness of VAD selection with recommendations from vascular access nurses using MAGIC evidence-based guidelines in clinical decision making. Achieving these goals could result in a decrease in CVAD use and a reduction in serious complications associated with CVADs. Objectives are aimed at improving the quality of patient care by using the latest evidence for vascular access recommendations for appropriateness. Improved quality of care can reduce health care costs by preventing complications that prolong length of stay for patients and require additional treatment.

Methods

The purpose of this quality improvement project was to equip vascular access nurses with the MAGIC evidence-based guidelines and knowledge necessary to support clinical decision making in VAD selection. The project was conducted at an urban, 700+ bed academic level 1 trauma medical center with a dedicated vascular access nurse team. The target audience for the project includes a specialized vascular access nurse team. This team, composed of 15 vascular access nurses, was informed about the project

through email and informational posters and given the opportunity to participate. The participants attended a one-hour focus-group education session (Appendix E) conducted by this author to obtain the MAGIC evidence-based guidelines and knowledge necessary to utilize this decision criteria in practice. In this session, the participants were provided with the MAGIC evidence-based resources (Appendix A-D) for use. Education content was designed to prepare the vascular access nurses to utilize the MAGIC resources to make recommendations for VAD selection for adult patients. The vascular access nurses were provided with printed MAGIC resources (Appendix A-D) to carry as reference cards in the clinical setting.

The vascular access nurses were asked to complete the Role in VAD Selection Pre-Survey (Appendix F), developed by this author, to measure perceived comfort in their role when making VAD recommendations based on available evidence. The MAGIC Criteria for VAD Selection Pre-Assessment (Appendix G), developed by this author based on key content from the MAGIC guidelines, was conducted before the education session to measure baseline knowledge of device selection criteria. The MAGIC Criteria for VAD Selection Post-Assessment (Appendix H), developed by this author based on key content from the MAGIC guidelines, was conducted after the education session to measure knowledge and understanding of use of the MAGIC guideline in clinical scenarios.

During the three-month data collection phase of the project, vascular access nurses responded to requests and orders from providers and bedside nurses for VAD placement and assessed appropriateness for the requested VAD using MAGIC evidence-based guidelines provided. Vascular access nurses discussed device selection criteria

with the provider or primary nurse and recommended the most appropriate VAD given patient characteristics and the MAGIC evidence-based guidelines. Vascular access nurses completed the MAGIC Criteria for VAD Selection Data Collection Tool (Appendix I), developed by this author with input for revisions from two vascular access nurse champions, to capture the impact of vascular access nurse recommendations on VAD placement. Data collection tools were deposited by vascular access nurses in a secure envelope in their department at the end of their shift. The Role in VAD Selection Post-Survey (Appendix K) was administered to vascular access nurses at the end of the project to measure a change in perceived comfort in their role when making recommendations for VAD selection.

The entire vascular access nurse team was trained by the facility to use ultrasound for VAD placement within one year of this projects' education session date. Data collected by the vascular access team was analyzed using descriptive statistics. All data was stored in a locked area that was accessible by this student and the primary investigator only.

Resources, Support, Risks, Threats

Strengths of the proposed project include the organization's designated vascular access nurse team consisting of nurses trained and certified in this specialty. This team places nearly all of the PICCs, MCs, and USGPIVs in the facility and works together to meet all of the inpatient vascular access needs. This small team works collaboratively and shares difficulties with practices and suggestions for improvement among the group. This team has available technologies and resources including ultrasound to assist with difficult VAD placement. The vascular access team services all inpatient areas of the

hospital, which is a strength for reaching the proposed change to patients in all specialties.

This proposed project site is currently on the journey to Magnet designation. Nursing leadership within the organization is strongly motivated to utilize evidence-based practices to improve the quality of care for patients. Nursing leadership supports innovative ideas from bedside clinicians as these practitioners are closest to patients and have the potential for great impact.

This organization may fall short in MC and USGPV appropriateness of use with underutilization and PICC appropriateness of use with overutilization. The current research demonstrates that MCs are underused and PICCs are over used and inappropriately used in inpatient care in similar settings (Chopra et al., 2015). The large size of this institution, including many individually functioning units and patient care areas, is a vulnerability for this project as there is an opportunity for areas to be unaware of evidence-based recommendations. Underutilization of MCs may be correlated with previous failed attempts to implement more frequent use and misconceptions about the appropriateness of use of these devices. Literature suggests that many MC programs have been initiated and subsequently fallen out of popularity due to misconceptions about their appropriateness for use (Pathak et al., 2015).

The expected overuse of PICCs and other CVADs places patients at risk for serious and costly complications. According to MAGIC recommendations, (Chopra et al., 2015) serious complication risk can be anticipated to nearly eliminated risk in patients who receive a MC, USGPV, or PIV in place of a CVAD. This is an opportunity for improving patient outcomes and decreasing vascular access related health care costs

for this population. Frequent attempts to place a PIV can be painful for patients and cause fear and distress contributing to decreased satisfaction with care. Replacing PIVs with an USGP IV or MC for patients who meet the criteria for a longer duration of access can reduce access attempts and create an opportunity for an increase in patient satisfaction scores. Reduced vascular access attempts can decrease additional time spent on multiple access attempts and increase nurse satisfaction.

The mission, vision, and values of this organization clearly prioritize high quality care, use of innovative technologies, and a collaborative approach to ensure optimal patient outcomes. The proposed project is designed to utilize the latest research and evidence-based recommendations to decrease serious complications for patients and improve outcomes in a cost-effective manner. This project involves collaborative work with a specialized vascular access nurse team to implement best practices to improve care and aligns well with the mission, vision, and values of the organization.

Expected Outcomes/ Evaluation & Dissemination Plan

Providing decision support that addresses patient specific situations to determine appropriateness of catheter selection, as well as quantifying current use can improve safety and quality of care for patients with VADs at this facility. Implementing a standard for appropriateness of catheter selection and use has the potential to impact CVAD use which can lower complication rates including CLABSI and DVT resulting in improved outcomes for patients and lower costs for this facility.

Dissemination of impact of this project will occur with nurses and other healthcare professionals at the project site. The impact of the proposed intervention could be of interest to vascular access nurses, bedside nurses, administrators, leaders,

educators, providers, and researchers. Project information can be disseminated through podium or poster presentation at the hospital during the annual presentation of quality improvement projects or the annual system-wide nursing conference. After measuring impact and dissemination of findings, strategies for continued improvement and sustainability of evidence-based practices will be explored as the main goal of the quality improvement project is to improve care for patients. Results from this project can be utilized to support the implementation of proposed order sets for consultations for VAD placement by vascular access nurses. This consultation service will create an opportunity for VAD placement to be driven by vascular access nurse teams entirely, without the need for provider approval or orders. Dissemination of this project to colleagues may increase awareness of the role of the DNP-prepared advanced practice nurse that has a unique skill set required to lead, develop, implement, and evaluate quality improvement projects in a variety of healthcare settings.

Results

Participant Demographics

The evidence-based MAGIC appropriateness guideline was launched for use by participants within the vascular access team on December 15th, 2018. Five out of fifteen (33%) of the vascular access nurses employed at the project facility participated in this quality improvement project. All participants were female. Two participating nurses held a bachelor's degree, two had an associate degree, and one had an associate degree in nursing and a bachelor's degree in another field. All of the participants had over twenty years of experience as a registered nurse, two had over thirty years. All of the participants had over six years of experience in the vascular access specialty, one had over twenty

years of experience in this specialty. Four out of five participants were certified as Vascular Access Nurses by the Association for Vascular Access (AVA) and one participant held an additional certification as a Certified Registered Nurse of Infusion (CRNI) by the Infusion Nurses Society (INS).

Current Evidence-Based Guideline Used

Four out of five nurses reported using some kind of evidence-based guideline in current practice. Two participants reported following the Infusion Nurse Society standards, one reported following the Association for Vascular Access guidelines, and one reported following both Infusion Nurses Society standards and the Association for Vascular Access guidelines. All participants referenced using a “hospital-based guideline” created by a previous manager that was at least three years old and did not include an evidence-based citation or reference list. Two nurses reported they were “somewhat familiar” with MAGIC guidelines, three reported they were “less than somewhat familiar” with the guidelines.

Role in VAD Selection Pre-Survey

When completing the Role in VAD Selection Pre-Survey (Appendix F) on confidence in practice, four out of five nurses reported they were “very comfortable” discussing vascular access device selection with providers and bedside nurses. One nurse felt “less than very, more than somewhat comfortable” in this discussion and specified difficulty with certain medications and lack of an organization-approved medication list. All nurses reported feeling “very confident” in their clinical recommendations for vascular access device selection. Four out of five nurses felt that providers and bedside nurses were “very likely” to value their recommendations regarding vascular access

device selection. One nurse felt that providers and bedside nurses were “less than very, more than somewhat likely” to value their recommendation, specifically reporting concerns with specialized intensive care unit providers.

MAGIC Criteria for VAD Selection Pre-Assessment

When completing the MAGIC Criteria for VAD Selection Pre-Assessment (Appendix G) to measure knowledge of five critical content areas of the MAGIC evidence-based guideline, all nurses were able to correctly identify the necessary factors to consider when choosing the most appropriate vascular access device for a patient scenario. For the second content area, all nurses were able to correctly identify the most appropriate lines for emergent situations, specifically addressing the inappropriateness of PICCs in these situations. When asked to identify the correct indication for MC placement, to assess the third content area, two nurses correctly chose MC for the given scenario. One nurse correctly chose MC, but indicated hesitation with this selection, specifically stating reasoning related to medications ordered in the future that may be inappropriate for this line, but the vascular access nurse is unable to monitor this line over time to intervene. One nurse incorrectly chose PICC, stating this is the safer choice as other medications that were inappropriate for MC could be ordered and administered in correctly, especially given the ICU setting addressed in the question. One nurse stated the question could not be answered because more information was needed, included patient’s specific vasculature and plan of care for this patient including future medications. For content question four, all nurses were able to appropriately identify indications for PICC use. When asked to identify appropriate removal of PICC, for the final content area, four out of five nurses incorrectly chose PICC to remain in place without an appropriate

indication. One nurse stated more information was needed, but still felt the PICC should remain. One nurse correctly chose to remove the PICC when it was no longer indicated for the patient.

MAGIC Criteria for VAD Selection Post-Assessment

On the MAGIC Criteria for VAD Selection Post-Assessment (Appendix H), all participants were able to utilize the MAGIC reference materials to select the most appropriate action for each content area (Table 1). Participants again reported that more patient specific information could be required when selecting the most appropriate VAD. On the post-assessment, all of the participating vascular access nurses reported hesitation for placing MCs and PIVs in certain scenarios because they felt that bedside nurses may not recognize the signs of infiltration as early as vascular access nurses. Participants reported concern that patients were at risk for these complications with inappropriate use of VADs placed and delayed identification and treatment of these complications.

Table 1. MAGIC Criteria for VAD Selection Pre and Post Assessment Results

MAGIC Criteria for VAD Selection Data Collection

MAGIC Criteria for VAD Selection Data Collection (Appendix J) was collected by participants using the MAGIC Criteria for VAD Selection Data Collection Tool (Appendix I) between December 15th, 2018 and March 15th, 2019. Forty-one device selection encounters were recorded. Fourteen VAD requests (34%) made by providers were inappropriate for the patient situation according to the MAGIC evidence-based guideline (Table 2). In all of these cases (100%), the vascular access nurse discussed a more appropriate VAD selection with the provider and for each encounter, the MAGIC evidence-based recommendation was followed.

Table 2. MAGIC Criteria for VAD Selection Results

In ten (24%) of these inappropriate cases, a PICC was ordered by the provider and another VAD, specifically a MC for seven of these cases, was placed instead after the vascular access nurse made a recommendation (Table 3). Six of the cases involving an inappropriate PICC order were related to medication duration of therapy. Two of the cases involved patients who already had appropriate access given their clinical scenario

and did not require a PICC. One case was inappropriately ordered in an emergency situation and one reasoning was not documented by the vascular access nurse.

Out of forty-one documented VAD requests, twenty-three (56%) PICCs were placed by vascular access nurses during the data collection period. Documented reasons for PICC requests and appropriate placement according to MAGIC evidence-based guidelines included orders for unspecified peripherally incompatible infusions including TPN (6), duration of infusion therapy (4), TPN specifically (3), chemotherapy (3), unable to obtain another form of access and VAD necessary for surgical intervention (1) (Table 4). Rationale for PICC placement was not specified in six cases.

Table 3. MAGIC Criteria for VAD Selection Inappropriate PICC Request Outcomes

Table 4. MAGIC Criteria for VAD Selection PICC Rational Results

Role in VAD Selection Post-Survey

The Role in VAD Selection Post-Survey (Appendix K) was conducted at the end of the data collection period. Four out of five participants completed the post-intervention survey. When assessing to what extent the MAGIC evidence-based guidelines supported decision making, two nurses felt the guidelines were “very supportive”, one reported “somewhat supportive”, and one reported “less than very, more than somewhat supportive”. When asked how comfortable participants felt using MAGIC evidence-based selection criteria to discuss vascular access device selection with providers/bedside nurses, one nurse felt “very comfortable”, two felt “somewhat

comfortable”, and one felt “less than very, more than somewhat comfortable”. When asked how confident nurses were in recommendations made regarding vascular access device selection when using the MAGIC evidence-based guidelines, one nurse felt “very confident”, two felt “somewhat confident”, and one felt “less than very, more than somewhat confident”. When asked how likely providers/bedside nurses were to value the vascular access nurses’ recommendation regarding vascular access device selection when using the MAGIC evidence-based guidelines, one reported “very likely”, two “somewhat likely”, and one “less than very, more than somewhat likely”.

When asked to provide open-ended response to explain how the MAGIC evidence-based selection criteria changed the vascular access nurses’ practice the following responses were obtained. One participant felt the guidelines did not change practice and “We base our decision on what medications and what the line is for”. One participant felt the guidelines didn’t significantly impact practice because “we already follow these guidelines, practices.” This participant did feel that this guideline would be beneficial for use on the inpatient units by nurses and providers. One participant expressed, “It’s important to have documented information to base any decisions on” and thought the guideline was helpful but did not specifically address if there was a change in practice. One participant did not provide a response to this question.

When asked to provide open-ended response to explain any perceived circumstances that were not addressed by the guidelines, the following responses were presented. One participant felt the criteria was too vague to address the complexities of a given patient scenario. One participant expressed need for guidelines to specifically address DVT prevention in specific situations, especially oncology, including

recommended length of time to wait before placing another PICC in an extremity with previous PICC-related DVT. This participant also felt the guidelines needed to address PICC placement for mastectomy patients. One participant reported no perceived circumstances that were not addressed by the guideline. One participant did not provide a response to this question.

Discussion

All participants began this project with a reported strong knowledge base and confidence in their practice specialty, including when making recommendations to providers and bedside nurses. All participants had many years of experience in nursing and in the vascular access specialty, specifically, four of the participants were certified in the specialty. This could have impacted their readiness and willingness to utilize a new evidence-based guideline, presented from someone outside of their department, that may contradict some of their current practices.

The pre-test demonstrated that vascular access nurses were knowledgeable in three of the key content areas addressed by the evidence-based MAGIC guidelines. The question assessing knowledge of appropriate indication for MC placement created an opportunity for impact in knowledge base as three nurses were unable to correctly address this content area. As participants gained knowledge regarding indications for MC placement, potential value specific to increase use of MCs in place of CVADs can positively impact patient outcomes through prevention of risk associated with inappropriate CVAD use.

For the question addressing PICC indications specifically, four nurses incorrectly identified indications for PICC removal and opted for PICC to remain in place when no

longer indicated. This created an opportunity for impact on knowledge base regarding appropriate indication for removal of PICC line for most participants. This increase in knowledge base for participants added potential value to project outcomes through decreased device utilization days and complications rates, as each day that a PICC remains in place without indication places patients at unnecessary risk for adverse outcomes (Chopra et al., 2012).

During the education session, all participants demonstrated ability to utilize the MAGIC reference materials to select the most appropriate action for each content area. The MAGIC evidence-based guidelines impacted the participant's knowledge base and can be used as reference by participants when making VAD recommendations. Per data collected through the MAGIC Criteria for VAD Selection Data Collection Tool (Appendix I), results indicate that providers and bedside nurses may not be adequately informed, or lack the resources necessary, to select the most appropriate VAD for a patient scenario, according to MAGIC evidence-based guidelines. Vascular access nurses demonstrated an impact on VAD selection as all inappropriate requests by providers or bedside nurses prompted an interprofessional discussion between vascular access nurse and provider or bedside nurse, which result in following the MAGIC evidence-based recommendation.

It can be argued that some of these discussions and recommendations may have been made by vascular access nurses, regardless of the implementation of MAGIC evidence-based guidelines, given their baseline knowledge of this subject area. It should be noted that seven inappropriate PICC requests resulted in placement of MCs by vascular access nurses. In comparison of pre and post-tests, three nurses gained

knowledge specifically related to MC indications and may not have appropriately recommended a MC for these patients without the MAGIC evidence-based guideline. This suggests that the MAGIC evidence-based guideline may be an effective tool for use by vascular access nurses to improve appropriateness of VAD selection in this acute care setting. These findings suggest equipping the vascular access nurses with the MAGIC evidence-based guidelines and knowledge may have prevented at least seven inappropriate PICC placements and, thus, is a valuable contribution to practice.

On post-survey, nurses felt the MAGIC evidence-based guidelines adequately supported clinical decision making. Participants felt comfortable and confident using the guideline, but this perceived comfort was, overall, less comfortable and confident than the reported comfort and confidence in making recommendations before guidelines were introduced. Vascular access nurses reported providers and nurses to be “more than somewhat likely” to value their recommendation when using the guideline, but this result is less likely than their perceived value before guidelines were introduced. Given the post-test demonstrating participants are able to use the guideline appropriately, this reduced confidence may indicate that the facility culture may not support participants to use this guideline appropriately.

Open-ended responses revealed that overall, nurses felt that evidence was important to guide practice, but did not feel that the guideline could adequately address specific issues pertaining to their institution and various populations and, therefore, could not be followed in all circumstances. Throughout the project, participants reported that the MAGIC evidence-based guidelines could not adequately address all of the characteristics involved in specific patient scenarios. The need for an individualized

approach in certain situations, particularly when attempting to estimate duration, is acknowledged in the MAGIC guidelines (Chopra et al., 2015).

Vascular access nurses reporting feeling hesitant to follow MAGIC evidence-based guidelines, specifically recommendations for MC placement, as they did not feel providers and bedside nurses were knowledgeable of appropriate use of VADs. At the project facility, the vascular access team nurses are unable to routinely monitor VADs after placement due to volume of VADs placed and limited number of vascular access nurses. Specifically, the participants are concerned that a VAD will be initially placed appropriately for a patient, but as the plan of care changes for that patient, the vascular access team is not prompted to reevaluate the appropriateness of the line. This leaves providers and bedside nurses to evaluate appropriateness on an ongoing basis without specialty consult from a vascular access nurse. The participants felt VADs may be used inappropriately in these situations and could result in patient harm. Vascular access nurses also expressed that bedside nurses and providers may have delayed insight into early signs of complications associated with inappropriate VAD use. Given the anatomical positioning of MCs, vascular access nurses fear patient harm resulting from an infiltration that may have been caught earlier with routine monitoring by the vascular access team.

In discussion of application, the MAGIC guideline authors acknowledge that appropriateness of VAD selection may be influenced by the health care setting (Chopra et al., 2015). The authors note that in particular facilities in which expertise and clinical support are limited, reliability of the VAD may be more important than appropriateness

for certain situations. This caveat parallels variances in practice between inpatient nursing units and the vascular access team at the project facility.

Given these concerns, vascular access nurses are more likely to place a PICC against recommendations if they suspect the plan of care will change for the patient and an MC will be used appropriately in the future. Vascular access nurses acknowledge a desire to routinely monitor all VADs placed, specifically MCs, as this would provide reassurance when placing a VAD according to recommendations. Vascular access nurses reported some personal accountability to patient harm resulting from VADs placed and felt a negative outcome associated with a VAD placed could reflect poorly on their practice. The participants may have perceived the risk of CLABSI associated with unnecessary PICC placement to be less severe than the potential risk of inappropriate use of a MC. The participants may have measured the personal accountability of a negative outcome of a VAD placed as an increased perceived risk. These challenges present significant barriers to sustained adoption of this practice guideline for use in the project facility.

Successful adoption of an evidence-based guidelines requires, ideally, that participants are practicing within a healthy work environment. The American Association of Critical Care Nurses (2016) maintains that six essential standards including, skilled communication, true collaboration, effective decision making, appropriate staffing, meaningful recognition, and authentic leadership must be in place to ensure a healthy work environment exists that will support patient safety and high-quality care. Feedback from participating vascular access nurses suggests the project facility may not fully uphold all standards required for practice in a health work environment. Participants

reported lack of education of team members to develop and master skilled communication to support interprofessional collaboration necessary to impact patient care. Interprofessional collaboration is best supported by health care organizations that evaluate team member accountability and address unwillingness to collaborate appropriately, with an emphasis on incorporating the decision-making authority of nurses (AACN, 2016).

Interestingly, data collection and reports from participants demonstrated a shared common goal among interdisciplinary team members, but differing opinions on how to achieve the goal. Vascular access nurses, providers, and bedside nurses all shared the common goal of reduced harm associated with vascular access devices, but not all members understood the weight and associated risk of each potential complication. Professionals from different disciplines had varying priorities in harm reduction practices and often disagreed about course of action. Without the support of a healthy work environment, vascular access nurses will be unable to utilize the decision support tools to sustain participation in true collaboration and effective decision-making in the health care team.

The participating nurses reported a lack of formal leadership assigned to the vascular access team for over two years. Without authentic leadership, the team lacked support, mentoring, enthusiasm, and performance review necessary to support advancing practice (AACN, 2016). Lack of leadership and any form of meaningful recognition created insurmountable barriers to sustaining utilization of MAGIC guidelines to support vascular access nurse recommendations including role dissatisfaction and decreased willingness to participate, resulting in a 33% participation rate for this project.

An optimal environment designed to support the autonomous practice of nurses is ideal when implementing a new evidence-based guideline that may change practice. According to Krein et al. (2017), hospitals with vascular access nurses who perceive their role in VAD decision-making to be valued by other members of the healthcare team have a lower frequency of inappropriate PICC use. Vascular access nurses who felt they were valued consultants had more experience in practice and placing PICCs than the other two role groups (Krein et al., 2017). Findings from these researchers indicate that understanding how to promote interprofessional collaboration is critical to ensuring improved appropriateness of PICC use in hospitals with vascular access teams (Krein et al., 2017). Further research is needed to better understand the association between the perceived role of the vascular access nurse and device utilization practices.

Conclusion

The MAGIC evidence-based guideline positively impacted the knowledge base of vascular access nurses regarding appropriate indication for MC use and removal of PICC for most participants. This increase in knowledge base for participants added potential value to improve appropriateness of VAD use and reduce risk of associated complications. Providers and bedside nurses may not be adequately informed, or lack the resources necessary, to select the most appropriate VAD, according to MAGIC evidence-based guidelines, given a patient scenario. Vascular access nurses' impact VAD selection and reduce patient exposure to unnecessary risk associated with PICCs through interprofessional discussion with the care team and evidence-based recommendation.

The MAGIC evidence-based guideline may be an effective tool for use by vascular access nurses to improve appropriateness of VAD selection in this acute care

setting. Equipping the vascular access nurses with the MAGIC evidence-based guidelines and knowledge may have prevented at least seven inappropriate PICC placements and, thus, is a valuable contribution to practice. Project facility culture may not support vascular access nurses to sustain use of the MAGIC guideline. Vascular access nurses acknowledge that evidence is important to guide practice, but do not feel that the guideline can adequately address specific issues pertaining to their institution and patient population and therefore could not always be followed. Successful adoption and sustained utilization of the MAGIC guideline within a facility requires an established healthy work environment that supports clinicians with access to evidence-based tools and knowledge necessary to support interprofessional collaboration around clinical decision making in VAD selection.

Recommendations

To achieve sustained appropriate use of the MAGIC guideline throughout the facility, this guideline must be implemented for use across disciplines and beyond the vascular access nurses. Expert recommendation from vascular access nurses is key to decision-making, but due to limited number of VAD specialty nurses available to place and monitor VAD use, sustained best practice in this area requires that all clinicians are able to access and utilize MAGIC decision criteria for optimal interprofessional collaboration and practice. Successful implementation and sustained appropriate utilization of the MAGIC guideline requires innovative leadership within an established healthy work environment.

The MAGIC guideline authors acknowledge important limitations to this appropriateness criteria including a limited understanding to how to best implement these

recommendations into practice. Chopra et al. (2015) emphasize the importance of implementing and utilizing the MAGIC guideline not as a final, conclusive document, but rather a guide that is everchanging and revised as new evidence emerges and updated practice recommendations are made available. Given the potential of CDS system technology to provide the user with continuously updated information at the point of care, this format is likely the most appropriate tool to accomplish the goals of MAGIC guideline implementation. With a clinical decision support tool in place, vascular access nurses will be empowered to drive change through new workflow processes that enhance quality of care. CDS tools have the ability to support healthcare clinicians at the point of care by providing evidence-based standardization support while allowing consideration to the individual needs of a patient (TIGER Initiative Foundation, 2014). Clinical decision support tools that utilize patient data and the latest evidence-based practice recommendations to create alerts and prompt action by providers could be incorporated into data collection tools of all kinds that are currently in place to prevent increased risk and missed care.

For this particular guideline, the CDS tool would ensure information is continuously updated for use beyond the vascular access nurses to clinicians from all disciplines throughout the facility. The CDS system provides the ability to incorporate pertinent patient-specific information to guide the clinician to the most appropriate device for the individual. Ideally, the CDS tool could alleviate some concerns of vascular access nurses by incorporating an alert warning for inappropriate use of VADs after placement.

The success of a CDS tool implementation is largely dependent on planning, support during implementation, and post implementation evaluation and optimization that

can only occur successfully in a healthy work environment. Nursing involvement in technology the CDS program design, implementation, and evaluation is essential to the success of the program (American Nurses Association, 2014). This evaluation process is crucial to completing the transition and sustaining the changes associated with CDS implementation. Usability surveys for end-users can be used to determine certain criteria be tailored to specific unit needs, these items could have been incorporated to meet the needs of the user and improve satisfaction with the tool.

Implementing a CDS with a user-centered design would be ideal to supporting optimal usability of the product. An iterative design involves having users evaluate a CDS tool's usability to determine effectiveness and efficiency in decision making and care processes and using feedback to make improvements (Nelson & Staggers, 2018). Designers have users interact with the tool to determine barriers and areas for improvement before implementation. Users are then encouraged to provide feedback to informatics leadership after using the system for several months. A user-centered design would include a focus on a deep understanding of the end-users including their practice environment, characteristics, and daily tasks (Nelson & Staggers, 2018). This understanding requires frequent contact with users throughout the design process to ensure the CDS tool will meet their needs. Given the large size of the project facility, champion users could be utilized to represent each specialty, discipline, and practice area to ensure a manageable process of implantation through peer support. Champions can be selected from each area to receive additional training and practice and provide peer-to-peer assistance to enhance adoption and use.

According to the TIGER Initiative Foundation (2014), the innovative nurse leader should possess the skills needed to effectively design and implement this clinical tool with input from key stakeholders. Future testing of the effectiveness and efficiency of a CDS tool like this will prompt leadership to make critical changes and improvements that will support the success and sustainability of the new technology. The innovative nurse leader employs professional interoperability, strong professional skills utilized to share knowledge, expertise, and meaningful information across disciplines (TIGER Initiative Foundation, 2014). More research and evaluation pertaining to the role of the vascular access nurse in VAD decision-making and the use of CDS systems in this specialty are needed.

Implications for Practice

Doctor of Nursing Practice prepared professionals are essential to leading and collaborating within a health care team to evaluate access to care, health care costs, quality indicators and patient outcomes, and established evidence-based standards (Hickey & Brosnan, 2016). Understanding nursing practice, how nurses' function as a member of the interdisciplinary team, and strategies to maximize the autonomy of practice to positively impact safety of care delivered and support sustained high-quality care is essential to future practice. Moving forward, health care organizations must function to support the delivery of safe, effective, patient-centered health care in a timely and efficient manner (Hickey & Brosnan, 2016). To do this, organizations must foster growth of health care professionals to practice to evidence-based standards, provide patient-centered care, and engage in interprofessional collaboration. Incorporating innovative CDS tools to support evidence-based practice within a healthy work

environment that fosters true interprofessional collaboration is essential to high-quality care and a sustainable health care system.

References

- Adams, D. Z., Little, A., Vinsant, C., & Khandelwal, S. (2016). The midline catheter: A clinical review. *The Journal of Emergency Medicine*, 51(3), 252-258.
- Al Raiy, B., Fakih, M.G., Bryan-Nomides, N., Hopfner, D., Riegel, E., Nenninger, T.... Khatib, R. (2010). Peripherally inserted central venous catheters in the acute care setting: A safe alternative to high-risk short-term central venous catheters. *American Journal of Infection Control*, 38(2), 149-53.
- American Nurses Association. (2014). Standardization and interoperability of health information technology: Supporting nursing and the national quality strategy for better patient outcomes. Retrieved from:
<http://www.nursingworld.org/positionstatements>.
- American Association of Critical Care Nurses (AACN). (2016). AACN Standards for establishing and sustaining healthy work environments. Aliso Viejo, CA: AACN.
- Berner, E.S. (2009). Clinical decision support systems: State of the art. Agency for Healthcare Research and Quality. Retrieved from:
https://healthit.ahrq.gov/sites/default/files/docs/page/09-0069-EF_1.pdf
- Caparas, J.V. & Hung, H.S. (2017). Vancomycin administration through a novel midline catheter: Summary of a 5-year, 1086- patient experience in an urban community hospital. *The Journal of the Association for Vascular Access*, 22(1), 38-41.
- Centers for Disease Control and Prevention (CDC). (2011a). Guidelines for the Prevention of Intravascular Catheter-Related Infections. Retrieved from
<https://www.cdc.gov/infectioncontrol/guidelines/BSI/index.html>

- Centers for Disease Control and Prevention (CDC). (2011b). CDC's Healthcare Infection Control Practices Advisory Committee (CDC/HICPAC) Guidelines for the Prevention of Intravascular Catheter-Related Infections. Retrieved from: <https://www.cdc.gov/hai/pdfs/bsi-guidelines-2011.pdf>
- Centers for Disease Control and Prevention (CDC). (2018). National and State Healthcare-Associated Infections Progress Report. Retrieved from: <https://www.cdc.gov/hai/data/portal/progress-report.html>
- Centers for Disease Control and Prevention (CDC). (2019). Bloodstream infection event (central line-associated bloodstream infection and non-central line associated bloodstream infection). Retrieved from: https://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf.
- Chopra, V., Kuhn, L., Coffey, C.E., Salameh, M., Barron, J., Krein, S.,... Saint, S. (2013). Hospitalist experiences, practice, opinions, and knowledge regarding peripherally inserted central catheters: A Michigan survey. *Journal of Hospital Medicine*, 8(6), 309-314.
- Chopra, V., Flanders, S.A., & Saint, S. (2012). The problem with peripherally inserted central catheters. *Journal of the American Medical Association*, 308(15):1527-1528.
- Chopra, V., Flanders, S.A., Saint, S., Woller, S.C., O'Grady, N.P., Safdar, N.,... Bernstein, S.J. (2015). The Michigan appropriateness guide for intravenous catheters (MAGIC): Results from a multispecialty panel using the RAND/UCLA appropriateness method. *Annals of Internal Medicine*, 163(6).
- Chopra, V., Kuhn, L., Ratz, D., Flanders, S.A., & Krein, S.L. (2016). Vascular nursing

- experience, practice knowledge, and beliefs: Results from the Michigan PICC1 survey. *Journal of Hospital Medicine*, 11(4), 269-275.
- Chopra, V., Kuhn, L., Ratz, D., Shader, S., Vaughn, V.M., Saint, S., & Krein, S.L. (2017). Vascular access specialist training, experience and practice in the United States: results from the national PICC1 survey. *Journal of Infusion Nursing*, 40(1), 15-25.
- Cortez, S., Dietrich, M.S., & Wells, N. (2016). Measuring clinical decision support influence on evidence-based nursing practice. *Oncology Nursing Forum*, 43(4) E170-E177.
- Curley, M.A.Q. (2007). *Synergy: The unique relationship between nurses and patients*. Indianapolis, IN: Sigma Theta Tau International.
- Fitch, K., Bernstein, S.J., Aguilar, M.D., Burnand, B., LaCalle, J.R., Lazaro, P., ... Kahan, J.P. (2001). The RAND/UCLA appropriateness method user's manual. Retrieved from: https://www.rand.org/pubs/monograph_reports/MR1269.html
- Gunst, M., Matsushima, K., Vanek, S., Gunst, R., Shafi, S., Frankel, H. (2011). Peripherally inserted central catheters may lower the incidence of catheter-related blood stream infections in patients in surgical intensive care units. *Surg Infect (Larchmt)* 12(4), 279-82.
- Hardin, S. (2013). The AACN synergy model. In Peterson, S. J. & Bredow, T.S. (Eds.), *Middle range theories: Application to nursing research* (pp. 294-305) (3rd ed.). Philadelphia, PA: Wolters Kluwer.
- Hickey, J. V., & Brosnan, C. A. (Eds.). (2016). *Evaluation of Health Care Quality for DNPs* (2nded.). New York, NY. Springer Publishing Company.

- Idemoto, B.K., Rowbottom, J.R., Reynolds, J.D., & Hickman, R.L. (2014). The AccuCath intravenous catheter system with retractable coiled tip guidewire and conventional peripheral intravenous catheters: A prospective, randomized, controlled comparison. *Association for Vascular Access*, 19(2), 94-102.
- Krein, S.L., Kuhn, L., Ratz, D., Winter, S., Vaughn, V.M., & Chopra, V. (2017). The relationship between perceived role and appropriate use of peripherally inserted central catheters: A survey of vascular access nurses in the United States. *International Journal of Nursing Studies*, 71, 28-33.
- Lewin, K. (1951). *Field theory in social science*. New York: Harper and Brothers.
- McEwen, M., & Wills, E. M. (2011). *Theoretical basis for nursing*. Philadelphia Wolters Kluwer Health/Lippincott Williams & Wilkins.
- Meyer, B.M. (2012). Developing an alternative workflow model for peripherally inserted central catheter placement. *Journal of Infusion Nursing*, 35(1).
- Moureau, N., Sigl, G., & Hill, M. (2015). How to establish an effective Midline Program: A case study of 2 hospitals. *Association for Vascular Access*, 20(3), 179-188.
- Nelson, R. & Staggers, N. (2018). *Health Informatics: An interprofessional approach*. (2nd Ed.). St. Louis, MO: Elsevier Mosby.
- Pathak, R., Patel, A., Enuh, H., Adekunle, O., Shrisgantharajah, V., & Diaz, K. (2015). The incidence of central line-associated bacteremia after the introduction of midline catheters in a ventilator unit population. *Infectious Disease in Clinical Practice* 23, 131-134.

- Smith, A. R. (2013). The AACN synergy model. In Peterson, S. J. & Bredow, T.S. (Eds.), *Middle range theories: Application to nursing research* (pp. 331-333) (3rd ed.). Philadelphia, PA: Wolters Kluwer.
- Stewart, M. W. (2018). Models and theories focused on competencies and skills. In Butts, J. B. & Rich, K. L. (Eds.), *Philosophies and theories for advanced nursing practice* (pp. 519-543). Burlington, M: Jones & Barlett Learning.
- Swaminathan, L., Flanders, S., Rogers, M., Calleja, Y., Snyder, A., Thyagarajan, R.,... & Chopra, V. (2018). Improving PICC use and outcomes in hospitalized patients: an interrupted time series study using MAGIC criteria. *BMJ Qual Saf*, 27(4), 271-278.
- TIGER Initiative Foundation. (2014). The Leadership Imperative: TIGER's recommendations for integrating technology to transform practice and education. Retrieved from: <https://www.himss.org/professionaldevelopment/tiger-initiative>
- Xu, T., Kingsley, L., DiNucci, S., Messer, G., Jeong, J.H., Morgan, B.,... & Yassin, M.H. (2016). Safety and utilization of peripherally inserted central catheters versus midline catheters at a large academic medical center. *American Journal of Infection Control*, 44(1), 1458-61.

Appendix A

The Michigan Appropriateness Guide for Intravenous Catheters (Chopra et al., 2015)

Venous access device recommendations for infusion of peripherally compatible infusates.

Device Type	Proposed Duration of Infusion			
	≤5 d	6–14 d	15–30 d	≥31 d
Peripheral IV catheter	No preference between peripheral IV and US-guided peripheral IV catheters for use ≤5 d			
US-guided peripheral IV catheter	US-guided peripheral IV catheter preferred to peripheral IV catheter if proposed duration is 6–14 d			
Nontunneled/acute central venous catheter	Central venous catheter preferred in critically ill patients or if hemodynamic monitoring is needed for 6–14 d			
Midline catheter	Midline catheter preferred to PICC if proposed duration is ≤14 d			
PICC		PICC preferred to midline catheter if proposed duration of infusion is ≥15 d		
Tunneled catheter				PICC preferred to tunneled catheter and ports for infusion 15–30 d
Port				

Appropriate

Neutral

Inappropriate

Disagreement

Figure Legend: IV = intravenous; PICC = peripherally inserted central catheter; US = ultrasonography.

Appendix B

The Michigan Appropriateness Guide for Intravenous Catheters (Chopra et al., 2015)

Venous access device recommendations for infusion of non-peripherally compatible infusates.

Device Type	Proposed Duration of Infusion			
	≤5 d	6–14 d	15–30 d	≥31 d
Peripheral IV catheter	Inappropriate	Inappropriate	Inappropriate	Inappropriate
US-guided peripheral IV catheter	Inappropriate	Inappropriate	Inappropriate	Inappropriate
Nontunneled/acute central venous catheter	Central venous catheter preferred in critically ill patients or if hemodynamic monitoring is needed for 6–14 d		Inappropriate	Inappropriate
Midline catheter	Inappropriate		Inappropriate	Inappropriate
PICC	Appropriate	PICCs rated as appropriate at all proposed durations of infusion		
Tunneled catheter	Inappropriate	Tunneled catheter neutral for use ≥15 d	No preference between tunneled catheter and PICC for proposed durations ≥15 d	
Port	Inappropriate	Inappropriate	Inappropriate	No preference among port, tunneled catheter, or PICC for ≥31 d

Appropriate
Neutral
Inappropriate
Disagreement

Figure Legend: IV = intravenous; PICC = peripherally inserted central catheter; US = ultrasonography.

Appendix C

The Michigan Appropriateness Guide for Intravenous Catheters (Chopra et al., 2015)

Venous access device recommendations for patients with difficult venous access.

Device Type	Proposed Duration of Infusion			
	≤5 d	6–14 d	15–30 d	≥31 d
Peripheral IV catheter	No preference between peripheral IV and US-guided peripheral IV catheters for use ≤5 d			
US-guided peripheral IV catheter	US-guided peripheral IV catheters preferred to peripheral IV catheters if proposed duration is 6–14 d			
Midline catheter	Midline catheters preferred to PICC if proposed duration is ≤14 d			
Nontunneled/acute central venous catheter	Central venous catheter preferred to PICC for use ≤14 d in critically ill patients			
PICC	Disagreement on appropriateness of PICC for durations <5 d	PICC use appropriate if proposed duration is ≥6 d; PICCs preferred to tunneled catheters for durations of 15–30 d		
Tunneled catheter			Tunneled catheter neutral for difficult IV access for use ≥15 d	No preference between tunneled catheter or port for use ≥31 d
Port				

Appropriate
Neutral
Inappropriate
Disagreement

Figure Legend:

IV = intravenous; PICC = peripherally inserted central catheter; US = ultrasonography.

Appendix D

The Michigan Appropriateness Guide for Intravenous Catheters (Chopra et al., 2015)

Venous access device recommendations for patients who require frequent phlebotomy.

Device Type	Proposed Duration of Infusion			
	≤5 d	6–14 d	15–30 d	≥31 d
Peripheral IV catheter	No preference between peripheral IV and US-guided peripheral IV catheter for use ≤5 d US-guided peripheral IV catheter preferred if venous access difficult			
US-guided peripheral IV catheter				
Midline catheter	Midline catheter preferred to PICCs if proposed duration is ≤14 d		Midline catheter neutral for frequent phlebotomy at this duration	
Nontunneled/acute central venous catheter	Central venous catheter preferred to PICC for use ≤14 d in critically ill patients			
PICC	Disagreement on appropriateness of PICC for durations <5 d	PICC use appropriate if proposed duration ≥6 d; PICC preferred to tunneled catheter for durations of 15–30 d		
Tunneled catheter			Tunneled catheter neutral for difficult intravenous access for use ≥15 d	
Port	Ports inappropriate for frequent phlebotomy, regardless of proposed duration of use			

Appropriate
Neutral
Inappropriate
Disagreement

Figure Legend: IV = intravenous; PICC = peripherally inserted central catheter; US = ultrasonography.

Appendix E

VAD Selection Education Session Outline

Location: Project facility vascular access breakroom.

1. Project Introduction- overview of project goals, invitation to participate, participants agree to participate.
2. Participants complete Role in VAD Selection Pre-Survey
3. Participants complete MAGIC Criteria for VAD Selection Pre-Assessment
4. Introduction to MAGIC research and summary of recommendations for practice
5. Introduction to MAGIC guidelines and discussion of use.
6. Participants complete MAGIC Criteria for VAD Selection Post-Assessment
7. Introduction to data collection tool and instructions for use.
8. Questions addressed, contact information provided for project concerns.
9. Reminder to complete VAD Selection Post-Survey at conclusion of project.

Appendix F

Role in VAD Selection Pre-Survey

Demographics:

1. Sex: Male Female Prefer not to respond
2. What is your highest degree completed? Diploma Associates Bachelors Masters
3. How many years have you practiced as a Registered Nurse?

5 years or less	6-10	11-15	16-20	21-25	26-30	30+
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4. How many years have you practiced as a vascular access nurse?

5 years or less	6-10	11-15	16-20	21-25	26-30	30+
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5. Do you hold a certification in a vascular access specialty? Yes No
 If yes, please specify:

Perceived Comfort in Role Questions

1. Do you currently follow an evidence-based guideline for vascular access device selection? Yes No If yes, please specify:
2. How familiar are you with Michigan Appropriateness Guide for Intravenous Catheters (MAGIC)?

Not familiar at all-1	2	Somewhat familiar-3	4	Very familiar -5
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3. How comfortable are you with discussing vascular access device selection with providers/bedside RNs?

Not comfortable at all-1	2	Somewhat comfortable-3	4	Very comfortable-5
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4. How confident are you in your recommendations regarding vascular access device selection?

Not confident at all-1	2	Somewhat confident-3	4	Very confident-5
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5. How likely are providers/bedside RNs to value your recommendation regarding vascular access device selection?

Not likely at all-1	2	Somewhat likely-3	4	Very likely-5
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Appendix G

MAGIC Criteria for VAD Selection Pre-Assessment

Indicate the most appropriate answer given the scenario provided.

1. Many factors are considered when choosing the most appropriate vascular access device for a patient including:
 - a. Duration of use, provider preference, time of day vascular access device is placed
 - b. Nurse preference, infusates ordered, availability of equipment
 - c. **Indication, anticipated duration of use, infusates ordered/anticipated**
2. A critically ill patient in the emergency room needs central access for resuscitation and vasoactive medications. The emergency room nurse pages the vascular access nurse for an urgent PICC placement. What is the most appropriate action?
 - a. Place the PICC as quickly as possible
 - b. Call the emergency room nurse to tell him that you will not place the PICC until the patient is moved to the ICU
 - c. **Discuss the most appropriate evidence-based options for vascular access with consideration to patient-specific needs with the provider and/or primary nurse including large-bore peripheral IV, introducer sheath, or centrally inserted central catheter**
3. The provider pages the vascular access nurse for assistance with access for an ICU patient. Upon review of the patients' chart the vascular access nurse finds that the patient has a history of difficult access with multiple peripheral catheter attempts, the ordered infusates are peripherally compatible, and the proposed duration of therapy is approximately 10 days. What is the most appropriate action?
 - a. **Place a midline and provide education to the primary nurse and patient as needed**
 - b. Educate and obtain consent from the patient to place a PICC
 - c. Collaborate with pharmacy and the provider to convert all medications to PO
4. The plan of care for a post-op patient includes TPN for at least 20 days. The provider places an order for a PICC. What is the most appropriate action?
 - a. Recommend the provider place centrally inserted central line as duration of use is only 20 days.
 - b. Recommend a midline to prevent CLABSI and report the inappropriate PICC order to the infection control department.
 - c. **Place a PICC after review of the chart and/or discussion with primary nurse or provider to confirm patient does not have any contraindications for PICC placement.**

5. A patient with a PICC no longer has non-peripherally compatible infusions ordered, has an anticipated discharge in 3 days, and PICC has not been used for an evidence-based clinical indication in 48 hours. Discussion with the primary nurse reveals that the PICC remains in place for morning labs for patient comfort. What is the most appropriate action by the vascular access nurse?
- a. No action required, this PICC can remain for the 3 days until discharge. Be sure to remove PICC before patient leaves the hospital.
 - b. Notify provider of evidence-based reason to remove PICC, confirm plan to remove PICC, remove PICC and assist with appropriate vascular access device placement for this patient if needed.**
 - c. Ask the primary nurse to remove the PICC when she has time.

Appendix H

MAGIC Criteria for VAD Selection Post-Assessment

Indicate the most appropriate answer given the scenario provided.

1. According to MAGIC evidence-based guidelines, many factors are considered when choosing the most appropriate vascular access device for a patient including:
 - a. Provider preference, duration of use, time of day vascular access device is placed
 - b. Indication, anticipated duration of use, infusates ordered/anticipated**
 - c. Infusates ordered, availability of equipment, primary nurse preference
2. A provider places a STAT request for PICC placement by the vascular access team for a hemodynamically unstable ICU patient. According to the MAGIC evidence-based guidelines, what is the most appropriate action?
 - a. Place the PICC as quickly as possible
 - b. Refuse to place the PICC and leave the unit
 - c. Discuss evidence-based options for vascular access devices with consideration to patient-specific needs with the provider and/or primary nurse including large-bore peripheral IV, introducer sheath, or centrally inserted central catheter**
3. The primary nurses request a midline for a patient. The vascular access nurse arrives to the unit to review the chart and discusses the plan of care with the primary nurse. The vascular access nurse finds that the ordered infusates are peripherally compatible, the patient has a history of difficult access with multiple peripheral catheter attempts, and the proposed duration of therapy is approximately 10 days. According to the MAGIC evidence-based guidelines, what is the most appropriate action?
 - a. Place a midline and provide education to the primary nurse and patient as needed**
 - b. Recommend a PICC
 - c. Ask pharmacy to convert all medications to PO
4. The vascular access nurse receives a request to place a PICC for a patient requiring TPN for at least 20 days. According to the MAGIC evidence-based guidelines, what is the most appropriate action?
 - a. Recommend a midline to prevent CLABSI.
 - b. Place a PICC after review of the chart and/or discussion with primary nurse or provider to confirm patient does not have any contraindications for PICC placement.**
 - c. Recommend provider place centrally inserted central catheter as duration of use is only 20 days.

5. A patient with a PICC no longer has non-peripherally compatible infusions ordered, has an anticipated discharge in 3 days, and PICC has not been used for an evidence-based clinical indication in 48 hours. Discussion with the primary nurse reveals that the PICC remains in place for morning labs for patient comfort. According to the MAGIC evidence-based guidelines, what is the most appropriate action by the vascular access nurse?
- a. No action required, this PICC can remain for the 3 days until discharge.
 - b. Ask the primary nurse to remove the PICC
 - c. **Notify provider of evidence-based reason to remove PICC, confirm plan to remove PICC, remove PICC and assist with appropriate vascular access device placement for this patient if needed.**

Appendix I

MAGIC Criteria for VAD Selection Data Collection Tool

Vascular Access Device (VAD) Data Collection Date _____ Unit _____

1. VAD **ordered/requested**: PICC Midline Peripheral IV Other _____

2. VAD **placed**: PICC Midline Peripheral IV Other _____

3. VAD requested appropriate according to MAGIC criteria? **YES** **NO**

If **YES**: PICC placed, rational:

Midline placed, rational:

Other action taken: _____

If **NO**, what action was taken?

_____ Discussion with provider/RN and MAGIC criteria followed.

_____ Discussion with provider/RN and VAD requested placed against MAGIC criteria.

_____ Other (please briefly explain):

Appendix J

MAGIC Criteria for VAD Selection Data Collection Results

Date	Unit	Ordered	Placed	App?	Reason
12/15/18	BB 6	PIV	PICC	No	UTO access, OR tomorrow
12/16/18	6A	PICC	ML	No	Needed for 5 days IV abx.
12/16/18	9A	PICC	PICC	Yes	HLOC, need meds & gtts
12/16/18	10B	PIV	ML	No	Unable to obtain PIV access
12/17/18	MICU	ML	ML	Yes	CT scan IV contrast
12/18/18	RICU	PICC	none	No	multiple PIVs, did not require PICC
12/19/18	9A	ML	PIV	No	
12/19/18	CCC3	PICC	PICC	Yes	
12/21/18	SICU	ML	ML	Yes	Insulin gtt
12/21/18	6A	PICC	ML	No	Meds ML compatible, 2 weeks duration
12/24/18	RICU	PICC	PICC	Yes	incompatible meds, TPN
12/25/18	JB 2N	ML	ML	Yes	UTO access for blood admin
12/27/18	RICU	PICC	PICC	Yes	Chemo
12/27/18	8A	ML	ML	Yes	Unable to obtain PIV access for IV fluid
12/28/18	MICU	PICC	CICC	No	STAT request
12/28/18	7B	PICC	PICC	Yes	
12/29/18	5ISC	PICC	PICC	Yes	TPN
12/29/18	BB 6	PICC	PICC	Yes	
12/29/18	JB 1N	PICC	PICC	Yes	IV abx 6 weeks
12/30/18	6B	PICC	PICC	Yes	UTO access, need for gtts
12/30/18	RICU	PICC	PICC	Yes	UTO access, incompatible meds
12/31/18	CCC2	PICC	ML	No	Duration of medication ordered
1/12/19	5ISC	PICC	PICC	Yes	D/C CICC, required duration
1/12/19	RICU	PICC	PICC	Yes	
1/12/19	6A	ML	PICC	No	
1/21/19	8B	PICC	PICC	Yes	Iv abx 6 weeks
1/21/19	RICU	PICC	PICC	Yes	
1/21/19	RICU	PICC	PICC	Yes	Multiple access needed for gtts
1/29/19	5ISC	PICC	PICC	Yes	TPN
1/29/19	ER	PICC	ML	No	
2/3/19	NCCU	PICC	ML	No	PICC not appropriate for med & duration
2/6/19	5ISC	PICC	PICC	Yes	TPN
2/6/19	8B	PICC	PICC	Yes	Chemo
2/6/19	8A	PICC	PICC	Yes	Chemo
2/6/19	RICU	PICC	None	No	Patient no longer needed access
2/7/19	6B	ML	ML	Yes	IV abx and duration appropriate for ML
2/7/19	RICU	PICC	PICC	Yes	Multiple gtts and IV abx, UTO access
2/7/19	6B	PICC	ML	No	IV abx and duration appropriate for ML
2/13/19	6A	PICC	ML	No	Inappropriate for meds and duration
2/17/19	MICU	PICC	PICC	Yes	Meds ordered required PICC

Appendix K

Role in VAD Selection Post-Survey

1. To what extent did the MAGIC evidence-based guidelines support your decision making when selecting the most appropriate vascular access device for a patient?

Did not support at all-1 2 Somewhat supported-3 4 Very supported-5

2. How comfortable are you with using the MAGIC evidence-based selection criteria to discuss vascular access device selection with providers/bedside RNs?

Not comfortable at all-1 2 Somewhat comfortable-3 4 Very comfortable-5

3. How confident are you in your recommendations regarding vascular access device selection when using the MAGIC evidence-based guidelines?

Not confident at all-1 2 Somewhat confident-3 4 Very confident-5

4. How likely are providers/bedside RNs to value your recommendation regarding vascular access device selection when using the MAGIC evidence-based guidelines?

Not likely at all-1 2 Somewhat likely-3 4 Very likely-5

5. How has the MAGIC evidence-based selection criteria change your practice? (open-ended)

6. Are there any other circumstances not addressed by the guidelines that you can share? (open-ended)