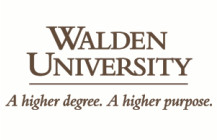

2017

Examining Venous Thromboembolism Post-Operative Orthopedic Care Using Electronic Order Sets

Kelly Remancus
Walden University

Walden University

College of Health Sciences

This is to certify that the doctoral study by

Kelly Remancus

has been found to be complete and satisfactory in all respects,

and that any and all revisions required by

the review committee have been made.

Review Committee

Dr. Mary Verklan, Committee Chairperson, Nursing Faculty

Dr. Maria Revell, Committee Member, Nursing Faculty

Dr. Marisa Wilson, University Reviewer, Nursing Faculty

Chief Academic Officer

Eric Riedel, Ph.D.

Walden University

2017

Abstract

Examining Venous Thromboembolism Postoperative Orthopedic Care

Using Electronic Order Sets

by

Kelly J. Remancus

MS, Walden University, 2011

BS, State University of New York Institute of Technology, 2000

Project Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctorate of Nursing Practice

Walden University

June 2017

Abstract

Venous thromboembolism (VTE) is a serious health concern of patients undergoing orthopedic surgery. Analysis of the study site semiannual reports from January 2014 through March 2015 indicated 10 VTE events in 546 orthopedic cases. The community hospital was classed as an outlier performing in the bottom 10th percentile when compared to other hospitals. To standardize the ordering of VTE prophylaxis, the hospital developed a postoperative electronic VTE order set. The purpose of this project was to assess the difference in orthopedic VTE occurrences in the postoperative total hip arthroplasty (THA) patients before and after the implementation of the electronic VTE order set. The goal of the project was to use an electronic retrospective chart review to evaluate if the order set implementation influenced the adherence to ordering mechanical and pharmacological prophylaxis in the THA patient. Differences in the ordering of VTE prophylaxis and VTE outcomes were evaluated using a retrospective review of 325 preimplementation order set cases and 406 postimplementation order set cases. This evaluation demonstrated that appropriate pharmacological prophylaxis ordering increased and orthopedic VTE occurrences decreased after the standardized electronic order set was implemented. Social change occurred through the empowerment of clinicians when empirical evidence was provided for use at the point of care, which positively impacted patient outcomes undergoing a common surgical procedure. VTE is no longer considered a routine postoperative orthopedic complication as technology-enabled solutions have proven to be appropriate tools to combat and prevent postoperative VTE complications.

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Acknowledgments

I wish to acknowledge the leadership and mentorship of my preceptor, and my project professor and chair, Dr. Mary Verklan. I would like to recognize the community hospital and the orthopedic practice where I am employed for their continued support with the project. I would like to thank my loving husband and son for believing in me and inspiring me to complete the project. I would not have been able to get to this point without their love, support, and understanding. I would also like to thank my very close friends and colleagues for being there through the rough patches when I just wanted to walk away. Your empathy, kindness, and ability to listen gave me the fortitude to push forward. I am blessed to have wonderful professors, family, and friends in my life. I cherish each and every one of you.

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Section 1: Nature of the Project

Introduction

Venous thromboembolism (VTE) poses a significant health and economic burden in U.S. hospitals (Merli, Ferrufino, Lin, Hussein, & Battleman, 2008). Orthopedic procedures have been found to have the highest prevalence of deep vein thrombosis when compared to other surgical procedures (Takai et al., 2013). The American College Surgeons National Surgical Quality Improvement Project (ACSNSQIP) 2014 Semiannual Report for the time period of January 2014–March 2015 reported 10 VTE events in 546 orthopedic cases. Based on the orthopedic VTE outcomes data, the study site hospital was classed as an outlier performing in the bottom 10th percentile when compared to other organizations.

Several years ago, the organization planned to improve orthopedic VTE outcomes by standardizing practice with electronic order sets. Due to a series of unfortunate circumstances, electronic order set activity for orthopedics was abruptly stopped. After leadership changes and new priorities, the electronic order set project began again with momentum to improve VTE outcomes. In July of 2014, the organization implemented computerized provider order entry (CPOE) order sets for the orthopedic service line. The purpose of this project was to assess the difference of orthopedic VTE occurrences in the postoperative total hip arthroplasty (THA) patient before and after implementation of the electronic VTE order set. In this study, I will discuss the factors that contributed to an increase in VTE, the nature of the project, and provide a solution to decrease the

incidence of VTE. In Section 1, I will discuss the context of the problem, project objectives, project questions, the significance of the project, implications for social change, and the assumptions and limitations.

Background and Context

The study site hospital organization is a regional tertiary facility comprised of 450 acute care beds and that employs over 900 nurses and a total of 4,500 employees. The hospital earned Magnet designation in 2005 and received redesignation in 2009 and 2015 by the American Nurses Credentialing Center. The community identifies the organization as a quality health care leader due to the fact it has received quality awards such as high ranking in orthopedics by the U.S. News and World Report, Thomson Reuters Top 100 Cardiovascular Hospitals, Blue Distinction Award for Treatment of Complex and Rare Cancers, Heart and Stroke Emergency Center Designation, Percutaneous Coronary Intervention by Accreditation for Cardiovascular Excellence, and Best Hospital of the Capital Region.

The organization underwent considerable change due to a local merger with three smaller acute care hospitals, while being simultaneously involved in a large enterprise-wide consolidation. The enterprise consolidation had established a ministry that employs over 80,000 associates. The community hospital organization continues to focus on delivering the highest quality comprehensive continuum of integrated health care services in the region.

The organization has been challenged with the integration of CPOE within their patient care delivery model. Due to a higher than expected VTE rate, the orthopedic specialty was chosen by the organization to implement electronic order sets. The ultimate goal of CPOE was to standardize postoperative VTE prophylaxis ordering across the specialty to reduce VTE outcomes in the orthopedic patient. The absence of standardized electronic VTE order sets resulted in wide variation of VTE prophylaxis ordering on paper-based order sets. Within the paper-based order set, a section was dedicated to VTE prophylaxis. Some prophylaxis orders were predefined and other orders had blank lines for providers to write in orders. Inconsistencies in the order sets resulted in varied VTE prophylaxis ordering by providers. A number of factors will be discussed that contributed to an increase in the rate of VTE in postoperative orthopedic patients.

Under the guidance of the enterprise, physician division chiefs, clinicians, and key subject matter experts across 19 acute care hospitals came together to standardize the postoperative orthopedic order set. The chief of orthopedics presented a persuasive argument to design the electronic order set to be all inclusive and support the ordering of VTE quality measures, which was supported by his orthopedic colleagues and interdisciplinary team. Through this process, relationships across the hospital system were fostered and strengthened within orthopedics. By the end of the order set design sessions, the orthopedic teams were pleased with their final product and were anxious to see the content be deployed in the electronic health record.

Weeks prior to releasing the order set for testing it was announced that the entire enterprise team was no longer with the system office. The order set project had come to an abrupt stop. Over the next couple of months, a new team was brought on-board to get the project back on track. The philosophy of the new team was different. They did not support an all-inclusive order set and insisted the order sets be pared down to specific content and be supplemented with additional modular order sets.

Without input from key stakeholders, the new system office leaders pared down the order set content and provided it to the chief of orthopedics. The VTE prophylaxis orders had been removed from the larger order set and were moved to a subspecialty folder named VTE prophylaxis that was not linked to the postoperative orthopedic order set. The format was very concerning to the chief of orthopedics because it would require the clinician to remember to use the VTE order set that is in a different area than the postoperative orthopedic order set. The chief of orthopedics did not agree with order set version and declined to accept and implement the electronic order set.

Eighteen months later, with a new chief of orthopedics the organization called upon the leader to implement CPOE. CPOE was necessary for two reasons. First, the VTE rate was higher than expected due to variation with paper orders. The pharmacy department reported receiving paper-based orders without VTE prophylaxis being ordered. When recognized, the pharmacy and nursing staff had to call providers for resolution. Computerized order entry offered the opportunity to standardize VTE prophylaxis ordering practices across orthopedics and improve VTE outcomes. The

second reason was to assist the organization to meet Meaningful Use (MU) II. For organizations to meet MU II, 60% of all medication orders had to be entered using CPOE (Centers for Medicare & Medicaid Services [CMS], 2012). Electronic medication orders were hovering at 48% which was below the 60% target. The significant volume of orthopedics patients would increase electronic medication orders above the target. The hospital organization convinced the system office to permit orthopedics to design a custom mega order set to meet their needs.

During the development of the organization's comprehensive postoperative orthopedic order set, the content design team incorporated VTE prophylaxis order set content for use in CPOE. The VTE prophylaxis content was developed with an interdisciplinary team by referencing the latest national guidelines from the American Academy of Orthopedic Surgeons (AAOS) and the American College of Chest Physicians (ACCP). To ensure medications within the VTE prophylaxis order set were well designed, the Institute for Safe Medication Practice's guidelines for order sets served as a style guide for the organization. The electronic order set content was vetted by the chief of orthopedics and the orthopedic interdisciplinary team. After several edits, the content was approved, signed off by the chief of orthopedics and submitted to the enterprise health system. The order set was approved and built within the clinical information system. Orthopedics went live with CPOE in July of 2014.

Problem Statement

The postoperative orthopedic VTE data derived from the hospital's ACSNSQIP 2014 Semiannual Report for the time period January 2014 to March 2015 reported 10 VTE events in 546 orthopedic cases. Based on the orthopedic VTE events reported, the organization was performing in the bottom 10th percentile (National Surgical Quality Improvement Project (NSQIP), 2015). Variation with paper-based order sets contributed to an increase in VTE, so to standardize practice, in July of 2014 the organization implemented CPOE to decrease orthopedic VTE outcomes. Since CPOE was implemented, orthopedic VTE outcomes were higher than expected. It was been determined that the electronic VTE prophylaxis protocol was not consistently used by providers. The orders were entirely skipped or only a portion of the protocol may be ordered. Both nursing and pharmacy identified errors of commission or omission with VTE prophylaxis. The organization did not know what the negative impact of the electronic order set was on the incidence of VTE.

The National Surgical Quality Improvement Project (NSQIP; n.d.) is a nationally benchmarked, clinical, risk-adjusted, and outcomes-based program to measure and improve care across surgical specialties nationally. The hospital organization's quality improvement plan initiative was to achieve a national benchmark performance in the 90th percentile for variation prophylaxis ordering practices. Since the implementation of the electronic VTE order set in July 2014, the organization did not assess if technology was contributing to an increase or decrease in the number of orthopedic VTE events. It was

important for the organization to appraise if there were any unintended consequences posed by not using the order set properly.

Purpose Statement

The purpose of this project was to assess the difference of orthopedic VTE occurrences in the postoperative THA patient before and after the implementation of the electronic VTE order set. In July 2014, the organization implemented electronic order sets for the postoperative orthopedic patient population. In an effort to align the electronic VTE order set content with the most recent clinical practice guidelines established by the AAOS, ACCP, and CMS MU requirements, the VTE prophylaxis order sets were embedded into the comprehensive admission postoperative orthopedic order set. The all-inclusive or mega order set approach was designed to support accurate ordering practices without having to leave the order set. Additionally, the approach was developed to augment clinician workflow and to encourage the ordering of important care requirements such as VTE prophylaxis for all postoperative orthopedic patients.

The NSQIP VTE events that occurred between January 2014–March 2015 comprised paper-based orders sets prior to July 1, 2014 and electronic order sets thereafter. During the electronic order set go-live in July 2014, clinical informatics nurses' at-the-elbow support was embedded in the Post Anesthesia Care Unit (PACU) to hardwire the new electronic order entry process and workflow for orthopedic providers. Adapting to new electronic workflow took time for clinicians. The transition from paper to electronic order entry resulted in both paper-based and electronic order entry of VTE

prophylaxis until the new workflow was hardwired and adopted. Order set utilization rates measured by the hospital demonstrated strong adoption of CPOE by the providers; however, the organization had not mandated providers to use CPOE.

Project Objectives

I had two project objectives for this DNP project. My first objective was to evaluate if technology influenced the adherence to ordering of mechanical prophylaxis in the THA patient. I reviewed each THA case to assess the adherence to ordering mechanical prophylaxis. Ordering adherence was measured by developing a tool that included patient demographic information and the type of mechanical prophylaxis ordered. To assess aspects of mechanical VTE guidelines, a comparison of the percent of adherence before and after implementation of the order set was calculated to evaluate if technology was affecting VTE occurrences.

My second objective was to evaluate if technology influenced the adherence to ordering pharmacological prophylaxis in the THA patient. I measured ordering adherence by developing a tool that included patient demographic information and the type of pharmacological prophylaxis ordered. To assess aspects of pharmacological VTE guidelines, a comparison of the percent of adherence before and after implementation of the order set was calculated to evaluate if technology is affecting VTE occurrences.

In this project, I defined the electronic VTE order set preimplementation period as January 1–June 30, 2014. The electronic VTE order set postimplementation period was defined as January 1–June 30, 2015. All THA cases during the two time periods defined

were provided by Stryker. Stryker is a contracted vendor that specializes in collecting patient reported outcomes and extracting important hospital metrics into a dashboard to evaluate opportunities for process improvement (Stryker Performance Solutions, 2013).

White and Dudley-Brown (2012) affirmed that outcomes data are crucial for providers to better understand the effects their services have on the patients they provide care for. The hospital organization's latest orthopedic VTE outcomes performance suggested there was a problem with VTE occurrences in the postoperative THA patient. After the implementation of the electronic order set, the anticipated outcomes included: (a) an increase in the ordering of VTE prophylaxis in the post-operative THA patient, (b) an increase in the adherence to mechanical and pharmacological prophylaxis guidelines in the postoperative THA patient, and (c) a decrease in VTE occurrence for postoperative orthopedic THA patients. My review of the VTE outcomes assisted in the analysis of technology strategies to support the translation of the latest VTE guideline recommendations into evidence-based practice.

Project Questions

Given the objectives of the project, I developed the following four questions to guide the study:

1. "What is the difference in the ordering of VTE prophylaxis before and after implementation of the electronic order"?
2. "What is the difference in ordering of mechanical prophylaxis before and after implementation of the electronic order set"?

3. “What is the difference in the ordering of pharmacological prophylaxis before and after implementation of the electronic order set”?
4. “What is the difference in orthopedic VTE occurrences before and after implementation of the electronic order set”?

During the development of the electronic order set content, there was debate over the most appropriate prophylaxis interventions for the THA patient. While the AAOS and ACCP guidelines were utilized to develop the electronic VTE prophylaxis order set, the grade of evidence for some recommendations were stronger than others, limited, or inconclusive. An evaluation of the electronic VTE order set compared to the recommendations of both national organizations was needed to ensure the order set was aligned to support clinicians in adhering to evidence-based practice. Completing an analysis of postoperative THA patients that developed a VTE was beneficial to assess common themes contributing to the development of VTE. Inconsistencies in the ordering of VTE prophylaxis may have influenced providers to adhere to the guidelines of one nationally recognized organization over another and alter their current VTE prophylaxis regimens.

Significance of the Project

When an organization commits to the philosophy of evidence-based practice, they are positioning themselves to deliver high quality care that is cost effective (White & Dudley-Brown, 2012). Despite good evidence, it is difficult work to drill into practice

changes that may improve patient safety. Within systems of care, knowledge translation needs to occur (White & Dudley-Brown, 2012).

According to Pronovost et al. (2009), "the boundaries between safety and the broader concept of quality remain poorly defined" (p. 330). In an effort to clarify broad clinical and policy domains that link to a safety scorecard, Pronovost et al. developed a Framework for Patient Safety Research and Improvement. The five framework domains include evaluating progress in patient safety, translating evidence into practice, measuring and improving culture, identifying and mitigating hazards, and evaluating the association between organizational characteristics and outcomes (Pronovost et al., 2009). Furthermore, Pronovost et al. argued that most research funding is spent on understanding disease mechanisms while there has been little research dedicated to identify effective, efficient, and safe delivery of care to patients.

Doctoral-prepared nurses must be prudent financial stewards to reduce the cost of care for patients and health care organizations. Expanding an individual's scope of knowledge related to the economics of healthcare will require continuous appraisal of the literature to stay current with newly proposed financial models such as value-based purchasing, which incorporate safe reliable care delivery where value is a function of both quality and cost (CMS, 2014a). Using technology solutions to assist in decreasing VTE occurrences in the postoperative THA patient improved quality outcomes, decreased cost, and ensured care that was both dependable and reliable.

Reduction of Gaps

The Agency for Healthcare Research and Quality (AHRQ; 2014a) reported deep vein thrombosis (DVT) may increase hospital length of stay by 2 to 5 days and result in excess costs of about $7,500. Pulmonary embolism (PE) can increase hospital length of stay by more than 5 days, result in an intensive care unit admission, and incur additional costs of more than $10,000 (AHRQ, 2014a). After a major surgical procedure, the risk of DVT and PE is approximately 20% for patients that did not receive prophylaxis (Baser, 2011). If patients do not receive the appropriate prophylaxis, patient safety issues, poor outcomes, and financial implications for the organization could be incurred.

The number one strategy to improve patient safety for patients at risk of VTE is the use of appropriate prophylaxis (AHRQ, 2014a). To ensure appropriate prophylaxis is utilized, clinicians must adhere to clinically appropriate evidence-based methods of prophylaxis. The AAOS (2011b) and ACCP (2012) both provide lengthy guidelines on the prevention and management of VTE prevention including suggestions for individual assessment of patients when choosing the specific thromboprophylaxis strategy. The hospital organization did not evaluate if the electronic VTE prophylaxis order set content was aligned to support the provider in selecting the most appropriate thromboprophylaxis based on AAOS or ACCP guidelines. Additionally, cases were not reviewed to identify themes for patients that developed a VTE following elective hip arthroplasty.

A retrospective content review of VTE cases for the elective hip arthroplasty population can provide insight into the adherence to national guidelines,

thromboprophylaxis ordering patterns, and assist in the detection of errors of omission and commission. To determine if the actual practice of thromboprophylaxis ordering was consistent with AAOS and ACCP recommendations, I expected the project to reveal where variation and/or deviation from the order set existed when ordering VTE prophylaxis, the patient specific risk of VTE, and if the prophylaxis was aligned with either AAOS or ACCP evidence-based guidelines.

Implications for Social Change

VTE is a serious health concern. Beckman, Hooper, Critchley, and Ortel (2010) acknowledged known risk factors such as increased age, immobility, surgery, and obesity are a public health problem that needs attention. In 2007, within six European countries, a total of 465,715 cases of DVT and 295,982 cases of PE were estimated (Cohen et al., 2007). Of the combined cases, deaths related to VTE were 370,012 or 49% (Cohen et al., 2007). More recent data in the United States indicates 900,000 people are affected by VTE each year and nearly 300,000 die from the disease (Dasta et al., 2015). By 2050, the number of adults with VTE is estimated to double to 1.82 million in the United States (Dasta et al., 2015). Despite efforts to increase awareness of VTE, health care providers can underrecognize the condition.

The ultimate goal of this project was to assess if the electronic order set influenced the provider's adherence to ordering VTE prophylaxis and decreased VTE in the THA patient. VTE is preventable and needs to be taken seriously. With this project, I sought to inform providers that inconsistent use of the order set contributed to a delay or

omission in prophylaxis ordering. Providers needed to assess their current practice and consider effective approaches to promote best practice prophylaxis use and prevent patient harm resulting from VTE.

The social change realized across the organization was that unsafe medical care is not acceptable. Patients should not be harmed when receiving care in the organization. It was necessary for healthcare providers to learn more about the burden and causes of VTE and adopt best practices to ensure safe patient care. Accepting VTE as a routine postoperative surgical or orthopedic complication is no longer acceptable. Raising public awareness and developing a comprehensive public health approach that leverages technology to combat and prevent VTE could reduce complications and unnecessary deaths. Developing a comprehensive training module for clinicians, patients, and families on VTE prevention could be the first step to raise awareness and engage the public to understand why VTE prevention is critical for improvements in patient outcomes.

Definition of Terms

In the healthcare field, many terms are commonly used. Depending on the context of the information, terms can be misinterpreted or have more than one meaning. In the following subsection, I will define the terms referenced throughout the project study:

American Recovery and Reinvestment Act (ARRA): An act passed in 2009, that earmarked $22 billion for the adoption of electronic health records (EHRs), with a goal of 100% adoption in all practice settings by the year 2014 (The White House, 2009).

Computerized provider order entry (CPOE): The process of entering medication orders and other physician's instructions electronically using a computer-based system to ensure standardized, legible, and complete orders (Al-Dorzi et al., 2011, p.1).

Deep vein thrombosis (DVT): Formation of one or more blood clots in the body's large veins, most commonly the lower leg or calf (Office of the Surgeon General; National Heart, Lung, and Blood Institute, 2008).

Electronic health record (EHR): An electronic version of a patient's medical history that is maintained by the provider over time and may include all of the key administrative clinical data relevant to that persons care under a particular provider, including demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports (CMS, 2012, para. 1).

Health information technology (HIT): A broad concept that encompasses an array of technologies to store, share and analyze health information (U.S. Department of Health & Human Service, 2013).

Hospital acquired condition (HAC): A medical condition or complication that a patient develops during the hospital stay, which was not present on admission (CMS, 2015b).

Intermittent pneumatic compression device (IPCD): An inflatable cuff wrapped around the leg with an electrical pneumatic pump that inflates the cuff with air to increase femoral venous blood flow and venous emptying (Fujisawa, Naito, Asayama, Kambe, & Koga, 2003);

Meaningful use (MU): Using certified EHR technology to improve quality, reduce health disparities, engage patients and family, improve care coordination and population health, and maintain privacy and security of patient health information (U.S. Department of Health & Human Services, 2015).

Order set: Grouping of common predefined orders for a particular disease state (Cowden, Barbacioru, Kahwash, & Saltz, 2003).

Pulmonary embolism (PE): A portion of a blood clot breaks loose and travels into the blood stream, first to the heart and then to the lungs, where it can partially or completely block a pulmonary artery or one of its branches (Office of the Surgeon General ; National Heart, Lung, and Blood Institute, 2008).

Total hip arthroplasty (THA): A surgical procedure where the damaged bone and cartilage is removed and replaced with prosthetic components (American Academy of Orthopedic Surgeons, 2015).

Venous thromboembolism (VTE): DVT and PE are grouped together and referred to as VTE (Office of the Surgeon General; National Heart, Lung, and Blood Institute, 2008).

Assumptions and Limitations

As I developed and conducted the project, it was important to plan for and address assumptions. Assumptions are external factors that have the potential to influence the success of the project but are outside the control of the project leader (White & Dudley-Brown, 2012). My first assumption for this DNP project was that the order set has a positive influence on provider ordering practices for VTE prophylaxis. A second assumption was the order set has been fully adopted by the providers with 100% utilization of the electronic order set. My third assumption was that when used properly, the order set will decrease VTE in THA patients.

Limitations of the project included the fact that a 6-month period was reviewed before and after the implementation of the electronic order set to assess the difference in the occurrence of orthopedic VTE. A longer time period to evaluate the differences in the occurrence of orthopedic VTE may have been beneficial. Another limitation was the hospital organization had not mandated providers use CPOE. Encouraging providers to use CPOE was important to the project. Educating providers on measures of efficiency, such as medication turnaround time or time to first dose of prophylaxis, will be essential to demonstrate adoption of the order set (Classen, Avery, & Bates, 2007). A third limitation was when using the order set there was no alerting mechanism to the provider

if VTE prophylaxis was not ordered. The project identified that additional clinical decision support may be beneficial to ensure prophylaxis has been ordered.

Summary

Although preventable, VTE continues to be a major concern in the United States. Following orthopedic surgery, VTE is the leading cause of hospital readmission (Johnson & Riley, 2012). With the purpose of decreasing VTE, the hospital organization study site chose to standardize and drive practice improvements with electronic order sets. In this project, I conducted a comparison of VTE occurrences before and after implementation of the order set. The results of the project informed the organization that the electronic order set is working as designed to improve practice. The analysis I conducted revealed mechanical prophylaxis remained the same while the pharmacological prophylaxis increased, which resulted in a decrease of orthopedic VTE outcomes. Evaluating the impact of electronic order sets has led to safer and more reliable hospital and postacute care for orthopedic patients.

Section 2: Review of Scholarly Evidence

Introduction

Section 2 will include the literature review. In this specific literature review, I will discuss the pathophysiology, assessment, and risk factors of VTE in the postoperative orthopedic population. The past lack of evidence to recommend chemical prophylaxis and the more current emerging evidence demonstrating the efficacy of aspirin, enoxaparin, and IPCDs to prevent VTE in postoperative joint replacement surgery will also be discussed. The general literature review will also include a focused review of the AAOS and ACCP VTE prophylaxis recommendations for aspirin, enoxaparin, and IPCDs in the postoperative orthopedic population. The AAOS and ACCP are two nationally-recognized organizations that publish evidence-based clinical practice guidelines on preventing VTE disease in patients undergoing elective joint replacement surgery. In the general literature review, I will also discuss how CPOE and order sets can standardize VTE care, decrease variation, and improve patient outcomes. Lastly, I will use an accountable care organization (ACO) model to explore the problem of VTE in the postoperative orthopedic THA patient population and foster shared accountability among providers for the quality and cost of care.

Search Strategy

To perform the literature review, I accessed the following databases and libraries: AHRQ, OVID Technologies, Medline, PubMed Medline, Institute of Medicine (IOM), ProQuest Nursing and Allied Health Sources, Cumulative Index to Nursing and Allied

Health Literature (CINAHL), EBSCOhost, AAOS, ACCP, and the National Guideline Clearinghouse. Key search terms for the literature review included: *venous thromboembolism prophylaxis in orthopedic surgery, venous thromboembolism in total joint arthroplasty, venous thromboembolism in total hip arthroplasty and replacement, chemical prophylaxis in orthopedics, aspirin use in orthopedics, enoxaparin use in orthopedics, mechanical prophylaxis, intermittent pneumatic compression devices, clinical information systems, physician order entry, computerized provider order entry, electronic order sets, venous thromboembolism orthopedic AND hip arthroplasty, aspirin AND orthopedic surgery, aspirin AND total hip replacement, enoxaparin AND orthopedic surgery, enoxaparin AND total hip replacement, mechanical prophylaxis AND total hip replacement,* and *electronic order sets AND venous thromboembolism prophylaxis OR total hip arthroplasty*.

In the review, I located 65 articles. Twenty-five articles were rejected due to lack of pertinent information to the project. Forty studies I found included in the literature had publication dates from 1986 to 2015. The methodologies in the articles included classical, comparative, meta-analysis, randomized control trials, review, and systematic reviews. The content included controversy over using chemical prophylaxis versus aspirin to prevent VTE in major orthopedic surgery, the use of enoxaparin and intermittent pneumatic compression devices in the prevention of postoperative VTE in major orthopedic surgery, AAOS and ACCP national guidelines and recommendations to

prevent postoperative VTE in major orthopedic surgery, and the benefits of clinical information systems and electronic order sets to standardize physician practice.

Review of Literature

The clinical practice of prescribing thromboprophylaxis by orthopedic surgeons following THA surgery is not standardized. Within the last 10 years, hospital oversight groups require hospitals to monitor and report orthopedic VTE rates (AHRQ, 2014a). Improving VTE rates has prompted hospitals to work with orthopedic surgeons to implement evidence-based practices that can be standardized and hard wired within clinical information systems (Cohen et al., 2007). Guidelines published by the AAOS and ACCP are broad and provide multiple options for pharmacological prophylaxis. After reviewing the guidelines, orthopedic surgeons may have differing opinions on which type of chemical prophylaxis to order following surgery. I will discuss the literature produced within the last 20 years as it has long been debated.

Pathophysiology of Venous Thromboembolism (VTE)

Abnormal blood flow, blood vessel wall, and blood clotting components, known jointly as Virchow's triad can cause the formation of thrombus (Turpie, Chin, & Lip, 2002). Prolonged periods of immobility or confined bed rest can result in blood flow abnormalities or venous stasis (Turpie, Chin, & Lip, 2002). One of the extrinsic factors triggering the clotting cascade is damage to the epithelial cell lining if the blood vessel (Snyder, 2008). As blood clots develop "the damaged endothelium attempts to maintain vascular integrity by adhesion and aggregation of platelets" (Snyder, 2008, p. 225). As

clotting progresses, the final step is the formation of thrombin, which leads to the conversion of fibrinogen to fibrin and the formation of a fibrin clot (Arcangelo & Peterson, 2006).

Pain, erythema, tenderness, and swelling of the affected extremity are common signs of DVT. DVT of the lower extremity is usually swollen with the circumference of the calf larger than the unaffected calf (Turpie, Chin & Lip, 2002). Compression ultrasonography is the noninvasive test of choice to confirm the diagnosis of clinically-suspected DVT (Turpie, Chip & Lip, 2002). Sudden shortness of breath, pleuritic chest pain, or collapse with shock in the absence of other causes are common signs of PE (Snyder, 2008). If thrombus separate from the vessel wall, it becomes an embolus (Turpie, Chin & Lip, 2002). The clot travels through the circulation until it lodges in a blood vessel where the blood flow is blocked and tissues or organs are deprived of oxygen (Snyder, 2008). PE is one the most serious complications in the orthopedic surgery population (AHRQ, 2014b). Pulmonary angiography testing is the gold standard to confirm the diagnosis of clinically-suspected PE (Turpie, Chin & Lip, 2002).

Venous Thromboembolism (VTE) Assessment and Risk Factors

With major orthopedic surgery, VTE is considered an important complication that is associated with significant morbidity and mortality (Cionac Florescu et al., 2013). Orthopedic patients are more vulnerable to VTE due to several prothrombotic processes such as: coagulation activation from tissue and bone injury, venous injuries, heat due to cement polymerization, reduced emptying intra-or postsurgery, and immobilization

(Cionac Florescu et al., 2013). In the absence of prophylaxis almost half of the patients undergoing elective total hip or knee replacement surgery develop VTE (Anderson & Spencer, 2003). PE is the most common postoperative complication in THA and is attributed to half of the postoperative deaths (Cionac Florescu et al., 2013).

Unique to orthopedic surgery is that the VTE risk period begins at surgery and extends beyond hospitalization into the postacute care setting, which prolongs the period of thromboprophylaxis (Cionac Florescu et al., 2013). Thrombus formation can take several days or weeks and is often detected days or weeks after hospital discharge (Snyder, 2008). Cohen et al. (2008) argued that despite the availability of evidence-based guidelines for VTE prophylaxis, assessment of patients who may be at risk is not consistently undertaken at both international and national levels. Currently, there is no way to predict which postoperative orthopedic patients will develop VTE. Educating patients and their care givers on the signs and symptoms of VTE may provide a public health benefit.

Risk factors for VTE should be evaluated by the orthopedic surgeon prior to arthroplasty surgery. While the literature is not specific for VTE risk factors in THA patients, there is strong evidence of overall VTE risk factors that include age greater than 50, myeloproliferative disorder, dehydration, congestive heart failure, active malignancy, hormonal replacement, moderate to major surgery, prior history of VTE, impaired mobility, inflammatory bowel disease, active rheumatic disease, sickle cell disease, estrogen-based contraceptives, central venous catheter, acute or chronic lung disease,

obesity, known thrombophilic state, varicose veins/chronic stasis, recent postpartum with immobility, nephrotic syndrome, and myocardial infarction (AHRQ, 2014a). The presence of these risk factors emphasizes the importance of individualized VTE risk assessment. A prior history of VTE and undergoing elective hip or knee arthroplasty surgery may present the highest risk of VTE in orthopedic patients (Cohen et al., 2007).

An important aspect in the prevention and management of VTE is assessing patient risk for both VTE and bleeding in the preoperative period (Beckman, Hooper, Critchley, & Ortel, 2010). Data from the VTE assessment can be used to modify the type of VTE prophylaxis for optimal patient safety (Cohen et al., 2007). Regardless of patient factors, surgical procedure factors, such as length of surgery, presence of trauma, and orthopedic surgery, can have a significant impact on the risk of VTE (Dasta et al., 2015). Although no single VTE risk assessment has been prospectively validated as superior to another (AHRQ, 2014a), the Caprini VTE risk assessment is frequently used for surgical patients. I did not find a VTE risk assessment specifically tailored to orthopedic surgery patients in the literature. The Caprini VTE risk assessment is a point-based tool that is used to assess risk factors for the development of VTE in surgical patients (AHRQ, 2014a). The results of the score can be used by providers to stratify VTE risk and determine the type of prophylaxis for surgical patients.

Bleeding is considered a major potential complication of chemical prophylaxis and requires careful evaluation by the provider (Cohen et al., 2007). Types of VTE prophylaxis used during hospitalization include chemical and mechanical prophylaxis.

Chemical prophylaxis includes low-molecular-weight heparin, unfractionated heparin, vitamin K antagonist, fondaparinux, and antiplatelet agents (AHRQ, 2014a). Mechanical prophylaxis includes intermittent pneumatic compression, venous foot pumps, and graduated compression stockings (Cohen et al., 2008). Mechanical prophylaxis devices can reduce the formation of blood clots by increasing blood flow (Collins, MacLellan, Gibbs, MacLellan, & Fletcher, 2010). Pharmacological and mechanical prophylaxis can be used in combination for patients with increased VTE risk factors (AHRQ, 2014a).

Traditionally, providers have been responsible for assessment and prescribing VTE prophylaxis, while nursing's role has been limited (Collins et al., 2010). Nurses that are involved in direct patient care can have a pivotal role in the assessment and prevention of VTE. In the immediate postoperative period, nurses are providing direct patient care and conducting detailed patient assessments to ensure the patient is responding appropriately. If nurses are educated on the latest evidence-based practices in the assessment and prevention of VTE they can have a prominent role in changing practice to promote optimal patient outcomes.

Lack of Evidence to Recommend Chemical Prophylaxis

Warwick, Williams, and Bannister (1995) analyzed the records of 1,162 patients who had a primary or revision THR performed between 1990 –1991. The purpose of their study was to determine the frequency of fatal and nonfatal PE and DVT 6 months after surgery. Routine chemical prophylaxis was not used during this time; antiembolic stockings and early mobilization was the standard practice (Cohen et al., 2008). Of the

1,162 patients, four or .34% developed fatal PE, 14 or 1.2% developed symptomatic PE, and 22 or 1.89% developed DVT (Warwick et al., 1995). The researchers concluded that in the absence of routine chemical prophylaxis, the fatal PE rate was low after total hip replacement (THR) (Warwick et al., 1995). The results of the study did not provide sufficient evidence to recommend thromboprophylaxis after hospital discharge. The large cohort of 1,162 patients that were treated by 12 consultant surgical teams at one specialized center would be considered a strength of the study. Evaluating the results of this study could contribute to orthopedic surgeons' reluctance to ordering chemical prophylaxis within the standardized electronic order set. The results of Warwick et al.'s study support this project because thromboembolism prophylaxis in total hip replacement surgery has been a controversial issue with orthopedic surgeons. Within the hospital organization study site, orthopedic surgeons had differing opinions over which agent to use routinely for chemical prophylaxis. To promote routine use of chemical prophylaxis an electronic order set was developed.

Fender, Harper, Thompson, and Gregg (1997) found that the use of chemical prophylaxis did not affect the overall mortality or fatal PE rates. Of the 1,893 arthroplasties, 1,226 or 64.8% received some form of chemical prophylaxis and 667 or 35.2% received no chemical prophylaxis (Fender, Harper, Thompson & Gregg, 1997). For those with chemical prophylaxis, the mortality rate was 10 of 1,226 or .82% and seven of 667 or 1.05% for those without chemical prophylaxis (Fender, Harper, Thompson & Gregg, 1997). For those with chemical prophylaxis, the PE rate was 3 of

1,226 or .24% and 1 of 667 or .15% for those without chemical prophylaxis. The study concluded that with the use of chemical prophylaxis, there was no significant difference between mortality and PE rates. The type of chemical prophylaxis patients received is not reported in the study. Since patients were not randomized into a specific group with chemical prophylaxis there is no comparison of mortality and PE rates with other chemical prophylaxis agents. Evaluating the results of this study could contribute to orthopedic surgeon's reluctance to ordering chemical prophylaxis within the standardized electronic order set. The study supports the controversial matter that chemical prophylaxis may not have an impact on the incidence of VTE. For orthopedic surgeons practicing in the 1990s, the literature was not conclusive in demonstrating the efficacy of routine use of chemical prophylaxis to prevent VTE in total hip replacement surgery. Given the controversial issues, the organization reviewed recent literature and guidelines to develop evidence-based electronic order sets.

Efficacy of Aspirin to Decrease Venous Thromboembolism

During 1992 through 1998, 4,088 patients undergoing elective arthroplasty were randomized into the placebo-controlled group and into the aspirin group of the pulmonary embolism prevention (PEP) trial (PEP Trial Collaborative Group, 2000). The PEP study is considered a large and important study of aspirin after major orthopedic surgery. The purpose of the study was to prove or disprove if 160 mg of aspirin daily reduces the risk of PE and DVT (PEP Trial Collaborative Group, 2000). Of the 2,047 patients assigned to aspirin, 15 or .73% developed nonfatal DVT, eight or .39% developed non-fatal PE, and one or .05% developed fatal PE (PEP Trial Collaborative Group, 2000). Of the 2,041 patients assigned to placebo, 19 or .93% developed nonfatal DVT, eight or .39% developed non-fatal PE, and two or 1% developed fatal PE. The results of the PEP trial demonstrated that aspirin decreases the risk of DVT and PE by at least one third (PEP Trial Collaborative Group, 2000). The PEP study (2000) confirmed aspirin was an effective means of chemical prophylaxis and could be used routinely for patients at high risk of DVT/PE. The study supports that aspirin is effective in the prevention of VTE in postoperative orthopedic patients and should be considered as a standard prophylactic treatment. The agent was added to the organization's electronic order set as standard VTE prophylactic therapy for total hip replacement surgery.

The Antiplatelet Trialists' Collaboration (ATC) is a worldwide three-part overview of randomized trials of antiplatelet therapy. The authors used collaborative meta analyses to compare antiplatelet regimens. Part I and II of the ATC proved that

antiplatelet therapy, such as aspirin, reduces the risk of myocardial infarction, cerebral infarction and other arterial occlusion (Antiplatelet Trialists' Collaboration, 1994).

Part III of the ATC sought to determine the efficacy of antiplatelet therapy as prophylaxis to prevent DVT or PE in surgical and high risk medical patients (Antiplatelet Trialists' Collaboration, 1994). Previously, aspirin had not been an accepted method of treatment to prevent DVT or PE. The study included 53 trials with a total of 8,400 subjects who had an average of two weeks of antiplatelet therapy versus control in general or orthopedic surgery (Antiplatelet Trialists' Collaboration, 1994). Also included, were nine trials with 600 patients of antiplatelet therapy versus control in other types of immobility and 18 trials with 1,000 patients receiving one antiplatelet regimen over another. For elective orthopedic surgery, 18 randomized trials with 1,154 patients were identified (Antiplatelet Trialists' Collaboration, 1994). Elective orthopedic surgery patients that received aspirin therapy for two weeks observed a 49% reduction in DVT, while a reduction in PE of 51% was noted (Antiplatelet Trialists' Collaboration, 1994). The ATC Part III (1994) substantiated that aspirin reduces both the incidence of DVT and PE in elective orthopedic surgery patients, traumatic orthopedic surgery and patients having general surgery. Bleeding complications were not consistently measured; however, each collaboration suggested when using aspirin the risk of bleeding is small. Aspirin has been shown to protect against DVT, PE, and other vascular events. Additionally, aspirin is well known, accessible, and provides a low-cost option for elective orthopedic surgery patients to prevent against VTE. The study supports that

when aspirin is used for VTE prophylaxis in elective orthopedic surgery patients, it is both effective in the prevention of VTE and does not increase the risk of bleeding postoperatively. Based on the evidence of this important study, aspirin was added to the electronic order set as standard VTE prophylaxis for total hip replacement surgery.

The purpose of the Antithrombotic Trialists' Collaboration (2002) meta-analysis review was to determine the effects of antiplatelet therapy in patients with high risk of vascular occlusive events. A total of 287 studies were evaluated comprising 135,000 subjects to compare antiplatelet therapy versus control and 77,000 subjects in comparisons of different antiplatelet regimes (Antithrombotic Trialists' Collaboration, 2002). The results of the meta-analysis revealed that antiplatelet therapy protects against vascular events among patients with unstable angina, intermittent claudication, and atrial fibrillation (Antithrombotic Trialists' Collaboration, 2002). Of the 287 studies, 32 trials which examined PE found that antiplatelet therapy reduced the risk of fatal and nonfatal PE by 25% among patients undergoing orthopedic surgery (Antithrombotic Trialists' Collaboration, 2002). The study supports the efficacy of aspirin in reducing PE events for patients having orthopedic surgery. The evidence further supports aspirin as standard VTE prophylaxis in total hip replacement and was added to the electronic order set.

Efficacy of Enoxaparin to Decrease Venous Thromboembolism

Turpie et al. (1986) conducted a randomized controlled trial of a low-molecular weight heparin, enoxaparin to prevent deep vein thrombosis in patients undergoing elective hip surgery. Fifty subjects received enoxaparin and 50 received placebo.

Prophylactic treatment was begun postoperatively in the 50 subjects who received enoxaparin and the 50 who received placebo, and continued for 14 days. Thrombosis was identified in 6 of 50 or 12% in the enoxaparin group and in 21 of 50 or 42% in the placebo group. The results of the trial concluded that enoxaparin is an extremely effective and safe form of VTE prophylaxis for elective hip arthroplasty patients (Turpie et al., 1986). Randomized control trials provide the strongest empirical evidence of a treatment's efficacy, which affords physicians with the information to individualize patient treatments in clinical practice. The study supports the efficacy of enoxaparin in reducing VTE for patients having hip replacement surgery. Enoxaparin was added to the electronic order set as standard prophylaxis for total hip replacement patients that are identified to be at the highest risk of developing VTE.

In 1988, a randomized, double blind placebo controlled study, sought to compare the efficacy and safety of enoxaparin and standard heparin for VTE prophylaxis after elective hip surgery (Planes et al., 1988). A total of 237 subjects were randomized into either active or control treatment. One hundred twenty-four subjects were randomly assigned to the active treatment arm and received enoxaparin 40mg subcutaneously 12 hours prior to surgery and then daily for 14 days or until discharge from the hospital. One hundred thirteen subjects were assigned to the control treatment arm and received unfractionated heparin (UFH) 5,000 international units subcutaneously 2 hours before surgery and then every 8 hours for 14 days or until discharge from the hospital. For those receiving enoxaparin, deep vein thrombosis was identified in 15 of 120 or 12.5 % and 27

of 108 or 25% for those receiving UFH (Planes et al., 1988). It was concluded that treatment with daily enoxaparin significantly reduced the incidence of overall and proximal DVT than those treated with UFH three times a day (Planes et al., 1988). Randomized control trials provide the strongest empirical evidence of a treatments efficacy and assist physicians to modify clinical practice to improve patient outcomes. The study supports enoxaparin's efficacy in reducing DVT without increasing the risk of bleeding. The agent was added to the electronic order set for total hip replacement patients identified at high risk of developing VTE.

Levine et al. (1991) completed a double-blind, randomized, control trial comparing low molecular weight heparin (enoxaparin) with standard unfractionated heparin. The goal of the study was to evaluate the efficacy and safety of enoxaparin compared with heparin for the prevention of postoperative DVT in patients undergoing total hip replacement surgery. Six hundred sixty-five patients were randomized and received either enoxaparin 30 mg subcutaneously twice daily or standard heparin 7,500 units subcutaneously twice daily (Levine et al., 1991). The treatments were started 12 to 24 hours after surgery and continued for 14 days (Levine et al., 1991). Thrombosis occurred in 17.1% of the subjects that received enoxaparin and 19% of those given standard heparin (Levine et al., 1991). Bleeding complications occurred in 5.1% of subjects that received enoxaparin and 9.3% of subjects that received heparin (Levine et al., 1991). The study concluded that total hip replacement subjects who were administered enoxaparin had a lower rate of thrombosis and significantly less bleeding

than those that were administered heparin (Levine et. al., 1991). The study supports enoxaparin as an effective and safe agent in DVT prophylaxis for total hip replacement. Since the agent does not show evidence of increased bleeding complications it was included in the organization's electronic order set.

Bergqvist et al. (1996) conducted a prospective, randomized double-blind study for subjects undergoing elective hip replacement to evaluate whether anticoagulation for one month post-operatively with enoxaparin is more effective therapy than enoxaparin given only during the acute hospitalization period. Two hundred sixty-two subjects received prophylaxis against thrombosis with enoxaparin 40 mg subcutaneously daily during their hospitalization (Bergqvist et al., 1996). The first dose of enoxaparin was administered the evening prior to surgery. At discharge, subjects were randomly assigned to receive either enoxaparin or placebo once daily for 21 days (Bergqvist et al., 1996). The VTE incidence rate observed for the placebo group was 39% while the enoxaparin group was 18% (Bergqvist et al., 1996). The study concluded that extending prophylaxis with enoxaparin into the post-acute care setting significantly decreased VTE incidence in total hip replacement surgery (Bergqvist et al., 1996). Based on the results of the study, the organization's VTE electronic order set recommends enoxaparin for at least 21 days after hospital discharge for total hip replacement surgery.

Efficacy of Intermittent Pneumatic Compression to Decrease Venous Thromboembolism

Hull et al. (1990) completed a randomized trial to assess if calf and thigh compression devices were effective in preventing VTE after total hip replacement when compared with a control group that was given no prophylaxis. Thrombosis was identified in 77 of 158 or 49% of the control subjects versus 36 of 152 or 24% of subjects given intermittent compression (Hull et al., 1990). It was concluded that intermittent leg compression significantly decreased the frequency of thrombosis after total hip replacement surgery. Intermittent pneumatic compression devices were included in the organization's electronic order set as part of standard VTE prophylaxis therapy for all patients following total hip replacement surgery.

A prospective study of 502 total hip arthroplasty subjects conducted by Hooker, Lachiewicz, and Kelley (1999) sought to appraise the effectiveness of intermittent pneumatic compression in the prevention of VTE after total hip arthroplasty. All subjects had bilateral thigh-high anti-embolic stockings and intermittent pneumatic compression devices applied at the start of the procedure and were maintained throughout the post-operative period except for personal hygiene or participating in physical therapy (Hooker, Lachiewicz, & Kelley, 1999). Lower extremity ultrasound discovered that 23 of 502 or 4.6% of subjects developed an asymptomatic thrombosis, while 3 of 502 or .6% developed a symptomatic pulmonary embolism confirmed with a lung scan (Hooker et al., 1999). Hooker et al. (1999) reported 1% of subjects experienced minor bleeding

complications. It was concluded that the lower prevalence of both DVT and PE with intraoperative and postoperative intermittent pneumatic compression is comparable with that associated to chemical prophylaxis (Hooker et al., 1999). A weakness of the study was that it examined elastic compression stockings and intermittent pneumatic compression as prophylaxis against VTE, which makes it difficult to determine if one mechanical therapy is superior to another. The organization elected to add intermittent pneumatic compression devices to their electronic order set as standard VTE prophylaxis therapy following total hip replacement surgery.

Fujisawa, Naito, Asayama, Kambe, and Koga (2003) compared two different types of intermittent pneumatic compression devices for the prevention of thrombosis and leg swelling following total hip replacement surgery. Fifty-eight subjects were assigned to the calf-thigh pneumatic compression group and 63 were assigned to the plantar compression group (Fujisawa, Naito, Asayama, Kambe, & Koga, 2003). Seven days after hip replacement surgery, the circumference of the thigh was measured for both groups. The calf-thigh circumference ratio averaged 1.22% and the plantar averaged 3.19% (Fujisawa et al., 2003). The study concluded that calf-thigh pneumatic compression is more effective than plantar compression in decreasing swelling and is less likely to contribute in causing thrombosis due to decreased vein flow (Fujisawa et al., 2003). The organization and orthopedic surgeons agreed to add intermittent pneumatic compression devices rather than plantar compression to the electronic order set.

Ben-Galim et al. (2004) studied the efficacy of a battery operated and mobile intermittent pneumatic compression device compared to a commonly used intermittent compression device that was not portable. Twenty-five subjects were randomized into the mobile compression device and the nonmobile compression device to compare the efficacy of the device in preventing DVT after joint replacement surgery (Ben-Galim et al., 2004). Both groups also received the routine treatment of heparin 5,000 units subcutaneously twice a day for six days following surgery (Ben-Galim et al., 2004). Doppler ultrasounds were performed on post-operative day 6 for all patients and there were no reports of DVT or PE discovered in any of the 50 patients. The study concluded that mobile compression devices were not superior to nonmobile compression devices and both devices are effective in the prevention of VTE for patients after total joint replacement surgery (Ben-Galim et al., 2004). The organization and orthopedic surgeons decided that nonmobile intermittent pneumatic compression devices were appropriate for the postoperative total hip VTE electronic order set.

General Review of Literature

Venous thromboembolism, a disease process that encompasses DVT and PE (Baser, Sengupta, Dysinger, & Wang, 2012), is a serious medical condition affecting approximately 350,000 – 900,000 Americans every year (Streiff et al., 2014). Deep vein thrombosis are blood clots that occur in deep veins in the body, often the lower extremity while PEs occur when a clot breaks loose and enters the arteries of the lungs (Office of the Surgeon General (U.S.); National Heart, Lung, and Blood Institute (U.S.), 2008). Of

the people who develop VTE, approximately 100,000 die due to sudden death, and 30% - 50% with lower extremity DVT develop post thrombotic syndrome causing long term swelling, pain, discoloration, and ulcers in the affected extremity (Streiff et al., 2014). Furthermore, Streiff et al. (2014) report 10% -30% of people who survive the first occurrence will develop another VTE within five years.

According to CMS, VTE is considered one of most preventable causes of death in hospitalized patients (Centers for Medicare & Medicaid Services, 2014b). In 2012, CMS added VTE to the hospital acquired conditions (HAC's) reimbursement policies (Kohlbrenner, Whitelaw, & Cannaday, 2011). "Medicare, Medicaid, and private health plans alike are refusing to pay for complications that usually can be prevented by adopting the CMS HAC and the National Quality Forum never-event policies" (Kohlbrenner, Whitelaw, & Cannaday, 2011, p. 123). Hospital-acquired VTE care costs approximately $58, 627 per case (Kohlbrenner, Whitelaw, & Cannaday, 2011). Furthermore, Kohlbrunner, Whitelaw, and Cannaday (2011) reported in 2007 that health care facilities HAC costs accounted for 12.2% of the total liability costs. The Centers for Disease Control and Prevention (CDC) reported the United States spends $5to $8 billion per year on direct medical costs associated with VTE (CDC, 2011). The cost of VTE is expensive to the healthcare system and cannot be sustained.

Despite many efforts to increase awareness of VTE in hospitalized patients, it still occurs. In the quest to reduce VTE, clinical information systems may provide support for clinicians to deliver consistent and reliable quality patient care. Hardwiring clinical

processes into electronic systems promotes safety and reduces the ability of staff to ignore or work around necessary measures that could save someone's life and reduce the overall VTE cost to the healthcare system.

American Academy of Orthopedic Surgery (AAOS) Guidelines

The AAOS Preventing Venous Thromboembolic Disease in Patients Undergoing Elective Hip and Knee Arthroplasty Evidence-Based Guideline and Evidence Report (2011b) established clinical practice guidelines based on a systematic review of published studies on preventing venous thromboembolic disease in patients undergoing elective hip and knee arthroplasty. The AAOS report (2011b) provides a summary of the evidence rating methodology and description of the evidence strength to assist provider's decision making in the prevention of VTE. The evidence ratings have been classified by the AAOS as strong, moderate, limited, inconclusive, and consensus. The following table provides a summary of the clinical practice guideline evidence rating recommendations on preventing VTE for elective hip and knee arthroplasty patients.

Table 1

Recommendation Strengths, Descriptions and Clinical Implications According to the AAOS

Evidence Rating	Description of Evidence Strength	Implication for Practice
Strong	Evidence is based on two or more "High" strength studies with consistent findings in support of recommending for or against the intervention. A **Strong** (positive) recommendation means that the benefits of the recommended approach clearly exceed the potential harm, and/or that the strength of the supporting evidence is high. A **Strong** (negative) recommendation means that the quality of the supporting evidence is high. A harms analysis on this recommendation was not performed.	Practitioners should follow a **Strong** recommendation unless a clear and compelling rationale for an alternative approach is present.
Moderate	Evidence from two or more "Moderate" strength studies with consistent results, or evidence from a single "High" strength study recommending for or against the intervention. A **Moderate** recommendation means that the benefits exceed the potential harm (or that the potential harm exceeds the benefits in the case of a negative recommendation), but the quality/applicability of the supporting evidence is not as strong.	Practitioners should generally follow a **Moderate** recommendation but remain alert to new information and be sensitive to patient preferences.
Limited	Evidence from two or more "Low" strength studies with consistent results, or evidence from a single Moderate strength study recommending for or against the intervention. A **Limited** recommendation means that the strength of the supporting evidence is unconvincing, or that well-conducted studies show little clear advantage to one approach over another.	Practitioners should exercise clinical judgment when following a recommendation classified as **Limited**, and should be alert to emerging evidence that might negate the current findings. Patient preference should have a substantial influencing role.
Inconclusive	Evidence from a single low strength study or otherwise conflicting evidence that does not allow a recommendation to be made for or against the intervention. An **Inconclusive** recommendation means that there is a lack of compelling evidence that has resulted in an unclear balance between benefits and potential harm.	Practitioners should feel little constraint in following a recommendation labeled as **Inconclusive**, exercise clinical judgment, and be alert for emerging evidence that clarifies or helps to determine the balance between benefits and potential harm.

table continues

Evidence Rating	Description of Evidence	Implication for Practice
		Patient preference should have a substantial influencing role.
Consensus	The supporting evidence is lacking and requires the work group to make a recommendation based on expert opinion by considering the known potential harm and benefits associated with the treatment. A **Consensus** recommendation means that expert opinion supports the guideline recommendation even though there is no available empirical evidence that meets the inclusion criteria for systematic review.	Practitioners should be flexible in deciding whether to follow a recommendation classified as **Consensus**, although they may give it preference over alternatives. Patient preference should have a substantial role.

Note. From "Preventing Venous Thromboembolic Disease in Patients Undergoing Elective Hip and Knee Arthroplasty," by American Academy of Orthopedic Surgeons, 2011, *Evidence-Based Guideline and Evidence Report,* p. 36.

Within the AAOS report (2011b), recommendations of VTE management for pharmacological and mechanical prophylaxis discuss the three essentials. They are the use of pharmacological and mechanical prophylactic agents, the type of prophylactic strategy, and the duration of prophylaxis. The fifth recommendation of the AAOS report suggests the use of pharmacological agents and/or mechanical compression devices for the prevention of VTE disease in patients undergoing elective hip or knee arthroplasty, and who are not at elevated risk beyond that of surgery itself for VTE or bleeding. The grade of recommendation is moderate, which means that the benefits exceed the potential harm, but the strength of the supporting evidence is not as strong. The AAOS performed a network meta-analysis to assess which pharmacological prophylactic agent may be the most effective (AAOS, 2011b). The results of the analysis did not suggest that one type of pharmacological prophylaxis is superior over another. The AAOS (2011b) report further indicates that the current evidence is unclear about which prophylactic strategy is

optimal or suboptimal and is unable to provide recommendations for or against specific prophylactics in these patients. The grade of recommendation is inconclusive, which means there is lack of compelling evidence resulting in an unclear balance between benefits and potential harm (AAOS, 2011b). Table 1 provides a description of the evidence rating and implications of practice for an inconclusive recommendation.

In the absence of reliable evidence about how long to employ these prophylactic strategies, it is the opinion of the work group that patients and physicians discuss the duration of prophylaxis (AAOS, 2011b). The grade of recommendation is consensus, which, means that expert opinion supports the guideline recommendation even though there is no available empirical evidence that meets the inclusion criteria of the guideline's systematic review (AAOS, 2011b). Given the broad nature of the recommendations, the organization and orthopedic surgeons determined that there was important evidence to include aspirin, enoxaparin, and IPCDs in the electronic order set.

American College of Chest Physicians (ACCP) Guidelines

In 2012, the ACCP published Antithrombotic Therapy and Prevention of Thrombosis, 9th edition: CHEST Evidence-Based Clinical Practice Guidelines. The ACCP guidelines include the division of prevention into three major areas: medical patients, orthopedic surgery patients, and other surgical patients (Falck-Ytter et al., 2012). For this project, the ACCP guidelines that focus on optimal prophylaxis to reduce postoperative VTE in orthopedic surgery patients will be discussed. Criteria suggested by the Grading of Recommendations Assessment, Development and Evaluation (GRADE)

working group were used to evaluate quality of evidence. Randomized control trials start as high-quality evidence and observational studies as low-quality evidence (Agency for Healthcare Research & Quality [AHRQ], 2014b).

According to AHRQ (2014b) other factors that affect the rating of quality include the risk of bias; precision; consistency; directness of results; likelihood of publication bias; and presence of very large effects. The ACCP modification of the GRADE system differs only in that the quality of a body of evidence can be high (A), moderate (B), or low (C) (AHRQ, 2014b). "The formulation of recommendations considered the balance between the desirable and undesirable consequences of an intervention; the quality of the evidence; the variability in patient values and preferences; and, on occasion, resource use issues" (AHRQ, 2014b, para. 37).

When desirable effects were much greater than undesirable effects, the recommendations were graded as strong. Strong recommendations were labeled 1 and worded as "The expert panel recommends" (AHRQ, 2014b). "Recommendations were graded as weak when desirable effects were not clearly greater or less great than undesirable effects" (AHRQ, 2014b, para. 37). Weak recommendations were labeled as 2 and worded as "The expert panel suggests" (AHRQ, 2014b). The rating of the quality of evidence- high, A; moderate, B; or low, C is provided with the strength of each recommendation (AHRQ, 2014b). Table 2 provides a summary of the ACCP rating scheme for the strength of the recommendations on the prevention of VTE in orthopedic surgery patients.

Table 2

Strength of the Recommendations Grading System According to the ACCP

Grade of Recommendation*	**Benefit vs. Risk and Burdens**	**Methodologic Quality of Supporting Evidence**	**Implications**
Strong recommendation, high-quality evidence, Grade 1A	Benefits clearly outweigh risk and burdens or vice versa.	Consistent evidence from randomized controlled trials (RCTs) without important limitations or exceptionally strong evidence from observational studies.	Recommendation can apply to most patients in most circumstances. Further research is very unlikely to change confidence in the estimate of effect.
Strong recommendation, moderate-quality evidence, Grade 1B	Benefits clearly outweigh risk and burdens or vice versa.	Evidence from RCTs with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence from observational studies.	Recommendation can apply to most patients in most circumstances. Higher quality research may well have an important impact on confidence in the estimate of effect and may change the estimate.
Strong recommendation, low- or very-low-quality evidence, Grade 1C	Benefits clearly outweigh risk and burdens or vice versa.	Evidence for at least one critical outcome from observational studies, case series, or from RCTs with serious flaws or indirect evidence.	Recommendation can apply to most patients in many circumstances. Higher-quality research is likely to have an important impact on confidence in the estimate of effect and may well change the estimate.
Weak recommendation, high-quality evidence, Grade 2A	Benefits closely balanced with risks and burden.	Consistent evidence from RCTs without important limitations or exceptionally strong evidence from observational studies.	The best action may differ depending on circumstances or patient or society values. Further research is very unlikely to change confidence in the estimate of effect.
Weak recommendation, moderate-quality evidence, Grade 2B	Benefits closely balanced with risks and burden.	Evidence from RCTs with important limitations (inconsistent results, methodologic flaws, indirect or imprecise) or very strong evidence from observational studies	Best action may differ depending on circumstances or patient or society values. Higher-quality research may well have an important impact on confidence in the estimate of effect and may change the estimate.

table continues

Grade of Recommendation*	Benefit vs. Risk and Burdens	Methodologic Quality of Supporting Evidence	Implications
Weak recommendation, low- or very-low-quality evidence, Grade 2C	Uncertainty in the estimates of benefits, risks, and burden; benefits, risk, and burden may be closely balanced.	Evidence for at least one critical outcome from observational studies, case series, or RCTs, with serious flaws or indirect evidence	Other alternatives may be equally reasonable. Higher-quality research is likely to have an important impact on confidence in the estimate of effect and may well change the estimate.

Note. From "Prevention of VTE in Orthopedic Surgery Patients: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: Evidence-Based Clinical Practice Guidelines," by American College of Chest Physicians, 2012, *AHRQ National Guideline Clearinghouse*, para. 42.

The ACCP Guidelines for Prevention of VTE in Orthopedic Surgery Patients (2012) are more prescriptive in their recommendations for pharmacological and mechanical prophylaxis than the AAOS 2011 VTE Prevention Guidelines. In patients undergoing total hip or total knee arthroplasty, the ACCP (2012) recommends the use of low-molecular weight heparin such as enoxaparin and aspirin (Grade 1B) or an intermittent pneumatic compression device (IPCD Grade 1C). Low molecular-weight heparin such as enoxaparin is recommended and preferred to other pharmacological agents (Grade 2B/2C). During the hospital stay, IPCD's are recommended in addition to pharmacological prophylaxis (Grade 2C Falck-Ytter, et al., 2012). Pharmacological prophylaxis should be extended for up to 35 days after discharge from the hospital (Grade 2B Falck-Ytter, et al., 2012). Intermittent pneumatic compression devices or no prophylaxis is suggested for patients with increased bleeding risk (Falck-Ytter, et al., 2012).

Upon review of the ACCP 2012 VTE recommendations specific to orthopedic surgery patients, the organization and orthopedic surgeons were able to finalize how each prophylactic agent would be used following surgery. Aspirin was recommended for patients classified at routine risk, while enoxaparin was recommended for patients classified at high risk of developing VTE. IPCDs would be applied to all patients postoperatively before leaving the operating room. The organization and orthopedic surgeons reached consensus to include aspirin, enoxaparin, and IPCD orders in the postoperative electronic VTE order set.

Technology/CPOE

The landmark report To Err is Human published in 1999 by the Institute of Medicine (IOM), has prompted hospitals to closely examine care delivery models and implement strategies to reduce medical errors and improve patient safety. The IOM reported that preventable adverse events are a leading cause of death in United States hospitals, accounting for between 44,000 – 98,000 lives lost yearly due to medical errors (Kohn, Corrigan, & Donaldson, 2000). Furthermore, medication errors are cited as one of the most common errors in hospitals (Kohn, Corrigan, & Donaldson, 2000). One of the key strategies identified to improve medication safety is computerized provider order entry (CPOE). Electronic order entry benefits include not having to decipher illegible handwriting, clinical checking decisions made by providers at the beginning of the medication cycle, and decreased turnaround time from order placement to actual medication administration

It is no secret to healthcare that hospitals have been slow to adopt health information technology (HIT), specifically electronic health records (EHRs). One of the major factors of slow adoption of this technology is related to the cost of implementation and maintenance of the system while trying to maintain a positive financial performance (Encinosa & Bae, 2013). In the State of the Union Address in 2004, President Bush presented a HIT plan offering Americans EHRs within 10 years that would improve quality, decrease cost, and reduce preventable errors (The White House, 2004). In 2009 to stimulate the economy, President Obama proposed and signed a bill passing the American Recovery and Reinvestment Act (ARRA). Part of the ARRA initiative is to modernize healthcare by offering financial incentives to hospitals if they are using a certified EHR in a meaningful way as defined in the different stages of Meaningful Use (MU) criteria (The White House, 2009).

The patient safety organization Leapfrog (2015) recommends the use of computerized provider order entry (CPOE) to integrate guidance for the physician into the flow of patient care, via standard order sets. As part of a patient safety quality improvement initiative, organizations such as Johns Hopkins have developed multidisciplinary VTE prevention teams using technology to design evidence-based strategies to prevent VTE (Streiff et al., 2014). The Johns Hopkins team determined that paper-based order sets were difficult to use and developed computer-based VTE smart order sets (Streiff et al, 2014). The VTE smart order sets were inserted into all admission

and transfer order sets for all medical and surgical patients. Streiff et al. (2014) reported VTE prophylaxis increased to 85% with the addition of smart order sets.

Maynard and Stein (2010) also recommend embedding electronic VTE order sets into admission, transfer, and perioperative electronic order sets. The implementation of HIT, such as smart order sets can lead to efficient clinician workflow and improved quality patient outcomes. Providing appropriate protocol guidance within the electronic order set that enables efficient clinical decision making may lead to a reduction in orthopedic VTE outcomes.

Conceptual Framework

An appropriate model to explore the problem of VTE in the postoperative orthopedic THA patient population was the Accountable Care Organization (ACO) model. The triple aims of the ACO model underscores reducing cost, improving quality, and enhancing patient experience (McClellan, McKethan, Lewis, Roski, & Fisher, 2010). Accountable Care Organizations are groups of doctors, hospitals, and other health care providers, who come together to provide more coordinated, high quality care to Medicare patients at lower cost (McClellan et al., 2010).

A core principle of the ACO model is the implementation of a robust quality measurement strategy (McClellan et al., 2010). According to the AAOS (2011a), “The ACO model is the first attempt to link quality and patient experience to financial rewards when providers meet quality and cost containment benchmarks” (p. 8). Furthermore, AAOS (2011a) recommends the need for technology platforms and systems that will

enable data gathering, data integration, and public reporting of quality and cost outcomes will be required for ACOs to be successful. Developing a robust quality measurement strategy specifically related to VTE in the orthopedic population may instill public confidence that cost savings are directly linked to evidence-based nursing practice and care improvements.

An essential goal of an ACO is to ensure patients receive coordinated care at the right time while avoiding duplicative services and medical errors. As an ACO begins to deliver high quality care at less cost, the ACO can share in the savings realized in the Medicare program (CMS, 2015a). ACO models offer nurses the opportunity to act as care coordinators, communicators, quality improvement managers, and providers of advanced levels of care (Nursing Alliance for Quality Care, n.d.). Within the care coordinator model, nurse case managers have the opportunity the implement an evidence-based screening tool to identify orthopedic patients at increased risk for VTE and develop a plan of care to manage this risk prior to hospital admission, during the acute hospitalization, and the postacute care phase. Well-coordinated early identification and intervention by nurses may result in improved outcomes and overall VTE management for the postoperative orthopedic population.

Summary

Venous thromboembolism remains an important and serious complication for patients undergoing joint replacement surgery. Even though there are practice guidelines from the AAOS and ACCP on the prevention of VTE for orthopedic patients, the

guidelines are cumbersome, very lengthy and not aligned. Lack of consistent recommendations can cause confusion for providers over which pharmacological agent is most effective in preventing postoperative thrombosis. Practice guidelines support that a multimodal approach is necessary to decrease the risk of developing VTE. After review of the literature, the organization's orthopedic surgeons agreed to standardize VTE prophylaxis in the electronic order set. Aspirin was the agent of choice for patients at standard risk and enoxaparin was the agent of choice for patients at higher risk of developing VTE after hip replacement surgery. Intermittent pneumatic compression devices were also part of standard VTE prophylaxis therapy and were to be ordered for all postoperative hip replacement patients. Implementation of the evidence-based electronic order set increased the provider's adherence to ordering standard prophylactic treatment and decreased VTE orthopedic outcomes. The next section will discuss the project design and methods.

Section 3: Methodology

Introduction

Kettner, Moroney and Martin (2013) stated "the purpose of the program design phase is to put together that service or combination of services that appears to have the best possible chance of achieving the program's objectives" (p. 19). Obtaining input from key stakeholders on the design of this program was critical to its success. The hospital organization study site had been an outlier in orthopedic VTE outcomes with performance in the bottom 10th percentile nationally. The purpose of this project was to assess the difference of orthopedic VTE occurrences in the postoperative THA patient before and after implementation of the electronic VTE order set. There were two objectives for the project (a) to evaluate if technology influences the adherence to ordering of mechanical prophylaxis in the THA patient (b) to evaluate if technology influences the adherence to ordering pharmacological prophylaxis in the THA patient. In this section, I will discuss the project design, population and sampling, data collection, data collection tool, protection of human subjects, data analysis, and project evaluation plan.

Project Design and/or Methods

All primary total hip arthroplasty cases between the preelectronic order set implementation period of January 1, 2014-June 30, 2014 and the postelectronic order set implementation period of January 1, 2015-June 30, 2015 was provided by Stryker. Stryker is a contracted vendor that specializes in collecting and extracting important

hospital metrics into an outcomes dashboard. Stryker provided the hip arthroplasty cases to the hospital organization's chief medical information office (CMIO). The CMIO obtained information from the embedded analytics clinical information system. I calculated a comparison of the percent of adherence to pharmacological and mechanical prophylaxis before and after implementation of the electronic order set to evaluate if technology was affecting consistent ordering of prophylaxis treatment. The VTE occurrence rate was reported before and after implementation of the electronic order set. Stryker provided VTE occurrences for the pre- and postelectronic order set implementation period to assess if technology was positively or negatively impacting VTE outcomes.

Population and Sampling

I collected the target data from discharged patients that underwent a primary THA between January 1, 2014-June 30, 2014 and January 1, 2015-June 30, 2015. The project's inclusion criterion was that the patient underwent a primary total hip replacement procedure. Hip revision and hip fracture procedures were excluded from the project. Total hip replacement patients had a diagnosis of osteoarthritis or degenerative joint disease and had to meet the criteria for medical necessity. The participants ranged in age from 40 to 90 and included all types of insurance. The THA payer mix consisted of 40% commercial, 30% managed Medicare, 25% Medicare, 2% Medicaid, and 3% other. Approximately 400 THA procedures are performed within a 6-month period at the

facility. I included the electronic medical record for every patient who underwent a primary THA during the two defined time periods above.

Data Collection

The data provided by Stryker contained every primary THA procedure performed between January 1, 2014-June 30, 2014 and January 1, 2015-June 30, 2015. The data parameters comprised the participants' account number, admission date, discharge date, procedure type, VTE complications during admission, and readmissions within 30 days of discharge for VTE. The procedure data were delivered to the CMIO via an encrypted Excel file that required a password to access. The CMIO used patient account numbers provided by Stryker to query the embedded analytics database from the hospital organization's clinical information system. The CMIO used structured query language to pull cases in which VTE prophylaxis, mechanical, and/or pharmacological prophylaxis was ordered. The data were then compiled in an Excel spread sheet and sent to me. All participants were completely deidentified and assigned a patient number by the CMIO. From there, I analyzed the differences in ordering VTE prophylaxis, mechanical and pharmacological prophylaxis, and VTE outcomes before and after the implementation of the electronic order set.

Instruments

Data collection tool. I developed one of the data collection tools in Excel for the project (Appendix A) myself. The tool contained headings to capture the variables participant numbers assigned, admit date, discharge date, procedure type, VTE

complication during admission, VTE readmit within 30 days, VTE prophylaxis ordered, mechanical prophylaxis ordered, and pharmacological prophylaxis ordered. I developed the tool to have VTE complication during admission, VTE readmit within 30 days, and prophylaxis ordering have a corresponding yes or no entered to examine the difference in the percentages of ordering of the order set and the VTE outcomes before and after implementation of the electronic order set.

Protection of Human Subjects

I obtained approval from hospital administration, the chief medical officer, the chief of orthopedic surgery, and Walden University's Institutional Review Board (IRB) prior to beginning the project. The IRB approval number for this study is 03-30-17-0183526. I also completed The National Institutes of Health web-based training course "Protecting Human Research Participants" on February 16, 2014 (Certification Number 1404756). The key stakeholders were made aware of the purposes of the project and were given the opportunity to ask questions. I stored data collected for the project in a secure, encrypted, password protected file located on my computer hard drive. The computer was kept in a locked office that was accessible only to me. To comply with Health Insurance Portability and Accountability Act, all patient specific information was deidentified. In accordance with the organizational policy, protection of patient information was maintained at all times.

Data Analysis

I used descriptive statistics to analyze the data collected from the project. Descriptive statistics are numbers that are used to summarize and describe data (Grove, Burns, & Gray, 2013). The differences in the ordering of VTE prophylaxis, mechanical and pharmacological prophylaxis, and VTE outcomes both before and after implementation of the order set were analyzed and compared. The differences between the pre-and postorder set implementation results were displayed as a percentage change.

There were four project questions. The first project question was: What is the difference in the ordering of VTE prophylaxis before and after implementation of the electronic order set? I used descriptive statistics to determine and compare the percentage of orders for VTE prophylaxis and the percentage of orders with no VTE prophylaxis. The results were completed both before and after implementation of the electronic order set. A comparison of the change in percentage of VTE ordering adherence both before and after implementation of the order set were examined to determine if the order set promoted ordering adherence.

The second question was: What is the difference in the ordering of mechanical prophylaxis before and after implementation of the electronic order set? I used descriptive statistics to determine and compare the percentage of orders for mechanical prophylaxis only and the percentage of orders with no mechanical prophylaxis. A comparison of the change in percentage of mechanical prophylaxis ordering adherence both before and after

implementation of the electronic order set were examined to determine if the order set promoted mechanical prophylaxis ordering adherence.

The third question was: What is the difference in the ordering of pharmacological prophylaxis before and after implementation of the electronic order set? I used descriptive statistics to determine and compare the percentage of orders for pharmacological prophylaxis only and the percentage of orders with no pharmacological prophylaxis. A comparison of the change in percentage of pharmacological prophylaxis ordering adherence both before and after implementation of the electronic order set were examined to determine if the order set promotes pharmacological prophylaxis ordering adherence. I also completed another analysis with descriptive statistics to assess the percentage of orders for both mechanical and pharmacological prophylaxis ordering adherence before and after implementation of the electronic order set. This analysis indicated whether implementation of the order set resulted in VTE prophylaxis ordering for both agents.

The fourth question was: What is the difference in orthopedic VTE occurrences before and after implementation of the electronic order set? I calculated the percentage of participants that developed VTE either during hospital admission or were readmitted within 30 days of discharge with VTE using descriptive statistics to determine the percentage of VTE outcomes. A comparison of VTE outcomes both before and after implementation of the order set were completed to evaluate if technology influenced VTE ordering adherence and reduced VTE occurrences in THA patients.

Project Evaluation Plan

The plan-do-check-act (PDCA) or Deming cycle was an appropriate model to evaluate the project. The PDCA cycle is a sequence of steps to obtain valuable learning and knowledge for continuous improvement of a process or system (Taylor et al, 2014). The PDCA cycle is used within the hospital organization to continuously and objectively measure, monitor, evaluate, identify, and pursue opportunities to improve the outcomes of patient care, service delivery and minimize the chances of adverse outcomes and events. The organization's quality department has been using this model of evaluation for over 25 years because the steps are easy to follow and it represents a continual process to explore improvement. The PDCA model provided an opportunity for me to evaluate whether a standardized electronic VTE order set improved or worsened the adherence to ordering mechanical and pharmacological prophylaxis and orthopedic VTE outcomes. Analyzing the test of change informed me that sustainable improvement was possible and the process did not require modification. Figure 1 provides a visual representation of the PDCA Deming quality improvement cycle.

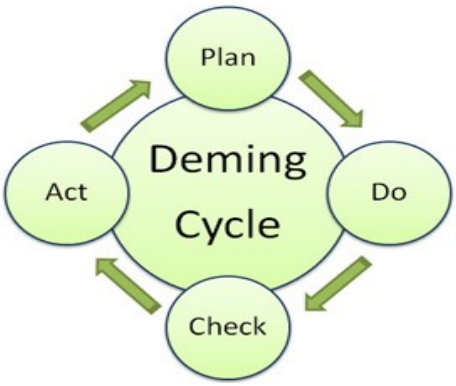

Figure 1. Illustration showing Deming's cycle plan do check act. From "Systematic Review of the Application of the Plan-Do-Study-Act Method to Improve Quality in Healthcare," by Taylor, McNichols, Nicolay, Daizi, Bell, and Reed, 2014, *BMJ Quality and Safety 23*(4), p. 292. Reprinted with permission.

Summary

In this project, I explored if technology influenced the adherence to ordering mechanical and pharmacological prophylaxis in the postoperative THA patient. I conducted an analysis using descriptive statistics to gather data on the adherence to ordering prophylaxis and VTE outcomes. The data were analyzed to determine the difference in ordering VTE prophylaxis after the order was implemented. A plan for the protection of human subjects was maintained throughout the project. The PDCA model was used to evaluate the project plan and the difference of orthopedic VTE occurrences before and after implementation of the electronic order set. The next section will discuss the findings and implications from the project.

Section 4: Findings, Discussion, and Implications

Introduction

The purpose of the DNP project was to assess the difference of orthopedic VTE occurrences in the postoperative THA patient before and after the implementation of the electronic VTE order set. The ACSNSQIP 2014 Semiannual Report for the period of January 2014 - March 2015 reported 10 VTE events in 546 orthopedic cases at the study site. Based on the orthopedic VTE outcomes data, the hospital organization study site has been classed as an outlier performing in the bottom 10th percentile when compared to other organizations. I conducted this quality improvement project initiative at a regional tertiary care facility comprised of 450 acute care beds. The organization has a large total joint replacement program with almost 3,000 arthroplasty surgeries performed annually.

THA cases and VTE complications were provided for this project by Stryker for the preelectronic order set period of January 1, 2014-June 30, 2014 and the postelectronic order set implementation period of January 1, 2015-June 30, 2015. Using the THA cases from Stryker, the hospital organization's CMIO queried the EHRs to determine if VTE prophylaxis and mechanical and pharmacological prophylaxis ordering adherence was followed before and after implementation of the electronic order set. The data were compiled in an Excel spreadsheet and sent to me for analysis. I analyzed the differences in ordering of VTE prophylaxis, mechanical and pharmacological prophylaxis, and VTE outcomes both before and after implementation of the order set and compared as a

percentage of change. In this section, I will discuss the project findings, practice implications, project outcomes, and project strengths and limitations.

Summary and Evaluation of Findings

With this DNP project, I aimed to evaluate the difference of orthopedic VTE occurrences in the postoperative THA patient before and after the implementation of the electronic order set. I had two objectives for this DNP project (a) to evaluate if technology influenced the adherence to ordering mechanical prophylaxis in the THA patient and (b) to evaluate if technology influenced the adherence to ordering pharmacological prophylaxis in the THA patient.

Given the objectives of the project, I developed the following four questions to guide the study:

1. "What is the difference in the ordering of VTE prophylaxis before and after implementation of the electronic order set"?
2. "What is the difference in ordering of mechanical prophylaxis before and after implementation of the electronic order set"?
3. "What is the difference in the ordering of pharmacological prophylaxis before and after implementation of the electronic order set"?
4. "What is the difference in orthopedic VTE occurrences before and after implementation of the electronic order set"?

In the following subsections, I will discuss the findings that resulted from my analysis.

Project Question 1

There were a total of 325 primary THA participants included in the preelectronic order set group for January 1, 2014-June 30, 2014 time period. Of the participants, 120 or 36.9% were men and 205 or 63.1% were women. The average age of men and women were 64 and 67 years, respectively. VTE prophylaxis was ordered for 281 of 325 or 86.5% of the participants. Forty-four of 325 or 13.5% of the participants did not have VTE prophylaxis orders consistent with either aspirin or enoxaparin.

There were a total of 406 primary THA participants included in the postelectronic order set group for January 1, 2015-June 30, 2015 time period. Of the participants, 186 or 46% were men and 220 or 54% were women. The average age of men and women were 62 and 67 years, respectively. VTE prophylaxis was ordered for 362 of 406 or 89.2% of the participants. Forty-four of 406 or 10.8% of the participants did not have VTE prophylaxis orders consistent with either aspirin or enoxaparin.

Prior to the electronic order set implementation, the ordering of VTE prophylaxis was 86.5%. The postelectronic ordering of VTE prophylaxis increased to 89.2%. The difference between the pre- and postelectronic order set represents an increase of 2.7%.

Project Question 2

Three hundred and twenty-five of 325 or 100% of primary THA participants had orders for mechanical prophylaxis with IPCDs prior to the electronic order set implementation. Four hundred and six of 406 or 100% of primary THA participants had orders for mechanical prophylaxis with IPCDs after the electronic order set was

implemented. Ordering adherence for mechanical prophylaxis with IPCDs has remained consistent with performance at 100%.

Project Question 3

Prior to the implementation of the electronic order set, 281 of 325 or 86.5% of primary THA participants had pharmacological VTE prophylaxis orders. Two hundred and eight of 325 or 64% of participants had aspirin orders and 73 of 325 or 22% had orders for enoxaparin. Forty-four of 325 or 13.5% of participants had orders for other pharmacological agents such as warfarin, dabigatran, and apixaban. These agents are not considered part of the agreed upon VTE prophylactic protocol by the orthopedic surgeons, and I placed them in the nonadherent category.

After the electronic order set implementation, 362 of 406 or 89.2% of primary THA participants had pharmacological VTE prophylaxis orders. Two hundred and seventy-seven of 406 or 68% of the participants had aspirin orders and 85 of 406 or 20.9% had orders for enoxaparin. Forty-four of 406 or 10.8% of participants had orders for warfarin, dabigatran, rivaroxaban, and apixaban. These agents are not considered part of the agreed upon VTE prophylactic protocol by the orthopedic surgeons and were not included in the standardized electronic order set. I placed the ordering of these agents in the nonadherent category.

For the preelectronic order set period, pharmacological VTE prophylaxis ordering adherence was 86.5%, compared to the postelectronic order set period, which was 89.2%. The difference observed between the two periods represents an increase of 2.7% in the

ordering of pharmacological prophylaxis. The percentage of nonadherence to ordering VTE pharmacological prophylaxis was 13.5% in the preelectronic order set period compared to 10.8% in the postelectronic order set period. The difference observed between the two periods is a reduction of 2.7%. The percentage of orders for both mechanical and pharmacological prophylaxis ordering adherence prior to the electronic order set was 281 of 325 or 86.5%, compared to the postelectronic order set period, which was 362 of 406 or 89.2%. The difference observed between the two periods represents an increase of 2.7% in the ordering of both mechanical and pharmacological prophylaxis. The increase is attributed to the ordering of pharmacological agents because the ordering of mechanical prophylaxis was 100%, both before and after implementation of the electronic order set.

Project Question 4

Before implementation of the electronic order set, 10 of 325 or 3.08% of primary THA participants developed a postoperative VTE. Two of 325 or .62% of VTEs occurred during hospital admission and 8 of 325 or 2.46% were readmitted within 30 days of hospital discharge. After implementation of the electronic order set, 3 of 406 or .74% of primary THA participants developed a postoperative VTE. One of 406 or .25% of VTEs occurred during hospital admission and 2 or .49% was readmitted within 30 days of hospital discharge.

For the preelectronic order set period, 3.08% of participants developed a VTE as compared to .74% for the postelectronic order set period. The difference I observed

between the two-time periods represents a decrease in VTE outcomes of 2.34%. For the preelectronic order set period, 2 of 325 or .62% of participants developed VTE during the postoperative hospital admission as compared to 1 of 406 or .25% for the postelectronic order set period. The difference observed represents a decrease of postoperative hospital admission VTE by .37%. For the preelectronic order set period, 8 of 325 or 2.46% of participants developed VTE within 30 days of hospital discharge as compared to 2 of 406 or .49% for the postelectronic order set period. The difference observed represents a decrease in the VTE 30-day readmission rate by 1.97%.

Discussion of Findings in the Context of the Literature

I had two objectives for this quality improvement initiative. My first objective was to evaluate if technology influenced the adherence to ordering of mechanical VTE prophylaxis in the THA patient. The findings revealed that mechanical prophylaxis was ordered 100% of the time both before and after implementation of the electronic order set. The results suggested that technology did not have a negative impact on mechanical prophylaxis ordering adherence, and performance of 100% was sustained with electronic order entry. While paper-based order sets were difficult for providers to use, the practice of ordering mechanical prophylaxis was hardwired into provider practice. With the practice change of electronic order entry, the ordering of mechanical prophylaxis was easily adopted and transferred with electronic order entry.

According to Cooley, May, Alwan and Sue (2012), studies have shown that when end users are involved in the design of order set content there is a greater likelihood of

successful CPOE implementation. Orthopedic subject matter experts were heavily involved in the content development and format of the electronic order set. Their involvement may have contributed to sustaining exemplary results with new technology rather than observing a decline in ordering adherence. Developing standard VTE order sets and protocols assures the patient receives the agreed upon standard (Maynard & Stein, 2010). By standardizing with electronic order sets, the need to remember all aspects of care for the clinician is reduced.

My second objective was to evaluate if technology influenced the adherence to ordering pharmacological VTE prophylaxis in the THA patient. The findings revealed that there was an increase of 2.7% in ordering the pharmacological prophylaxis protocol from 86.5% to 89.2%. Nonadherence to ordering the pharmacological prophylaxis protocol decreased by 2.7% from 13.5% to 10.8%. Based on these findings, the electronic order set has positively influenced pharmacological ordering adherence and decreased ordering outside of the protocol. Patients are more likely to be prescribed VTE prophylaxis with a standardized order set (O'Connor, Adhikari, DeCaire, & Friedrich, 2009).

The pre- and postelectronic order set time periods that I analyzed demonstrated that orthopedic VTE outcomes decreased by 2.34% from 10 to three occurrences in the postoperative THA patient. When integrated with technology, standardized care processes provide for more reliable consistent care delivery and better patient outcomes

(McCartney, 2014). Well-designed evidence-based order sets can transform clinical processes and clinician behavior.

The conceptual framework that I used for the DNP quality improvement project was the Accountable Care Organization (ACO) model. The triple aims of the ACO model underscores reducing cost, improving quality, and enhancing patient experience (McClellan, McKethan, Lewis, Roski, & Fisher, 2010). A core principle of the ACO model is the implementation of a robust quality measurement strategy (McClellan et al., 2010). The model supported the work of the project by leveraging technology to query the clinical information system to evaluate VTE prophylaxis ordering adherence and orthopedic VTE outcomes. Prophylaxis ordering adherence information and misses can be shared with providers in a timely manner to improve quality care, prevent VTE outcomes, and improve patient experience.

Implications

Policy

In 2008, the Surgeon General's call to action to prevent VTE declared that at least 350,000, and as many as 600,000 Americans develop VTE, and approximately 100,000 deaths are thought to be related to VTE (Office of the Surgeon General (U.S.); National Heart, Lung, and Blood Institute (U.S.), 2008). The Centers for Medicare and Medicaid Services (CMS, 2014a) and the Agency for Healthcare Research and Quality (AHRQ, 2014a) have reported that VTE is the most common preventable cause of hospital death.

Postoperative VTE is a common complication of surgical procedures that can lead to increased length of stay, excess mortality, and increased cost (Johnson & Riley, 2012).

The incidence of confirmed hospital acquired VTE ranges from 40% -60% among orthopedic surgery patients (Johnson & Riley, 2012). Despite this, not all patients receive an appropriate VTE prophylaxis due to a disproportionate fear of bleeding complications (Cionac Florescu et al., 2013). Given the staggering statistics of postoperative VTE in orthopedic surgery patients and the organization's prior poor performance, the decision to standardize care with the implementation of an electronic order set has demonstrated a decrease in postoperative orthopedic VTE outcomes for total hip arthroplasty patients.

Practice

The history of the literature demonstrates that chemical thromboembolism prophylaxis has been controversial in the prevention of postoperative VTE in orthopedic surgery patients (AAOS, 2011b). The PEP (2000) study and ATC (2002) meta-analyses provided strong evidence that aspirin reduces the incidence of VTE after major orthopedic surgery. Despite these results, the AAOS and ACCP guidelines were not consistent in their recommendations of aspirin to prevent postoperative VTE in THA patients.

The latest VTE prevention guidelines were published by AAOS in 2011 and ACCP in 2012. As evidence is acquired, it is important to evaluate the level of evidence and quality (American Nurses Association, 2015). The American Nurses Association (2015) notes there are numerous scales for levels of evidence ranging from three to seven

levels. The definitions of levels of evidence have not been standardized (American Nurses Association, 2015). Clinical practice guidelines published by two different nationally recognized organizations that lack standardized levels of evidence can be problematic for clinicians to fully appraise the evidence to prevent VTE disease in the postoperative orthopedic population. The clinical practice guidelines published by the AAOS and ACCP employ different levels of evidence that are not aligned in a standardized approach. Clinicians are challenged by inconsistencies in the literature, which may cause confusion when attempting to adopt evidence-based practices. After thorough review of the evidence, the organization determined aspirin was appropriate prophylaxis for postoperative orthopedic arthroplasty procedures and provider ordering adherence has increased with the electronic order set.

Research

The results of the DNP quality improvement initiative demonstrated that technology positively influenced VTE prophylaxis ordering adherence and reduced postoperative orthopedic VTE outcomes. Reducing postoperative and 30 day readmissions for VTE will have positive financial results for the hospital. According to Kohlbrenner, Whitelaw, and Cannaday (2011) hospital-acquired VTE care costs approximately $58,627 per case. Based on the results of the quality improvement initiative, there were seven less VTE's in the postelectronic order set group. This accounts for a total of $410,704 in savings for the organization. Venous thromboembolism is a preventable condition that requires additional research and

analysis by the organization to ensure all patients receive appropriate prophylaxis. Additional measures will be considered with effective system design and electronic alerting mechanisms at the right time of care processes, delivery, and evaluation, which can reduce and virtually eliminate a near miss for VTE prophylaxis (Streiff et al., 2014).

Social Change

The DNP quality improvement project impacted social change by decreasing the number of patients with postoperative VTE following THA surgery. Through the development and implementation of the project, I demonstrated the ability to appraise and critique the evidence in the context of the orthopedic patient. The orthopedic surgeons were very interested to learn since implementing the electronic order set that ordering adherence to VTE prophylaxis had increased and VTE outcomes decreased. The prevention and management of VTE continues to pose patient safety issues in most U.S. hospitals (Duff, Walker, & Omari, 2011). The results of the project have had a positive influence on the orthopedic surgeons because they are no longer willing to accept VTE as a normal complication and want to provide the safest care possible. The orthopedic surgeons have asked for their specific VTE prophylaxis ordering adherence reports and are committed to performing case reviews when the protocol is not followed. The project also encouraged nurses to identify when the protocol is not used and place a phone call to the provider to discuss and obtain appropriate orders. Future social change may also explore launching an orthopedic VTE prophylaxis campaign for patients and families to educate them on preventing a serious post-operative complication.

Project Strengths and Limitations

Strengths

One of the strengths of the quality improvement project is the sample size that was evaluated for the pre and post order set time periods. According to Grove, Burns, and Gray (2013) the sampling component is an important part of the project process that needs to be well thought out and described clearly. Specific inclusion and exclusion criteria were defined for the pre and postelectronic order set six month time periods that were evaluated. A total of 325 THA cases were examined for the preelectronic order set period of January 1 2014 through June 30 2014 and 406 THA cases were examined for the postelectronic order set period of January 1 2015 through June 30 2015.

A second strength of the quality improvement project was that it evaluated provider ordering adherence to VTE prophylaxis, mechanical, and pharmacological prophylaxis. Prior to this project, this type of data was not measured by the organization and shared with the providers. The orthopedic providers did not have knowledge of their baseline VTE prophylaxis ordering adherence. In the absence of a baseline compliance result, the orthopedic providers were unsure if the electronic ordering pathway would increase or decrease their level of compliance and improve VTE outcomes. The results of the DNP project proved that 100% ordering adherence was sustained for mechanical prophylaxis, chemical prophylaxis ordering increased, and VTE outcomes were reduced with implementation of the electronic order set.

Limitations

One of the limitations of the quality improvement project was that another six month period was not evaluated after the order set was implemented to assess if ordering adherence continues to advance and VTE outcomes continue to decline. Conducting the additional analysis would inform the providers and the organization if change has been sustained and hard wired into the daily workflow of the clinician. Reliable data collection and performance tracking is necessary for breakthrough and sustained levels of improvement (Maynard & Stein, 2010).

Another limitation of the quality improvement project is that the project focused only on THA cases. Orthopedic surgery is a well-established risk factor for VTE. Assessing total knee arthroplasty cases for the same time periods may provide additional insight into VTE ordering adherence and orthopedic VTE outcomes.

Recommendations for Remediation of Limitations in Future Work

Based on the results of the DNP quality improvement project there are several recommendations for future doctoral work. The first opportunity is to conduct a retrospective analysis on the VTE cases that occurred during the pre and postelectronic order set time periods. The review may uncover risk factors that were missed that may have led to the development of a VTE or if appropriate prophylaxis was prescribed. The second opportunity is to integrate a VTE risk assessment and score into the electronic order set. Incorporating a VTE risk assessment into the electronic order set would provide transparency to nurses and other clinicians of the patient's risk level and if the appropriate

prophylaxis was prescribed. Lastly, developing an educational campaign for nurses, patients, and families that VTE is an important and preventable public health concern is needed to raise awareness. Empowering patients and families to raise the issue of postoperative VTE with their providers may assist in preventing a negative outcome. Venous thromboembolism prophylaxis should be determined during the pre-operative surgical discussion with the provider and the patient. The information should accompany the patient upon arrival to the hospital and be reviewed again after the procedure. Patient knowledge and awareness may ensure consistent and reliable care processes in the prevention of VTE in the postoperative orthopedic patient.

Analysis of Self

As Practitioner

Throughout the development of the project, I became more knowledgeable of appropriate VTE prophylaxis for postoperative orthopedic patients and why orthopedic clinicians may be reluctant to ordering. I learned that key subject matter experts were not always familiar with recommendations from the literature and their practice may be lagging behind. In part, I believe this is because the guidelines are difficult to read and interpret. Often, there may be inconsistencies depending on who authored the content and this may lead to even more confusion and delays in implementing evidence-based practices. Simplifying the guideline content with application that is relevant to practice may assist clinicians in examining their current practice. The American Association of Colleges of Nursing (AACN, 2006) Essential VI, Interprofessional Collaboration for

Improving Patient and Population Health Outcomes holds competencies of effective communication and collaborative skills, analysis of complex practice issues, and consultative and leadership skills with interprofessional teams to create change in health care. The project has helped to further develop my communication and leadership skills. Taking time to understand why clinicians may be reluctant to change allowed me the opportunity to communicate and collaborate with them, which gave them confidence to use the electronic order set. I learned that clinicians are faced with many changes simultaneously and they need to have their voices heard or the changes risk being adopted and patients may have negative outcomes. The skills acquired throughout the DNP educational journey have prepared me to assess new evidence for integration into practice in a timely manner. The completion of the DNP project demonstrates the application of the DNP Essentials, which will provide the foundation for future advanced practice work.

As Scholar

With the development of the project, I have gained expertise in navigating the organization's complex health care system. Applying systems thinking at both the micro and macro levels enables the advanced-practice nurse to identify and implement new solutions to resolve practice issues (Zaccagnini & White, 2011). Conducting in depth literature reviews and presenting the information in a clear and succinct manner in the context of the organizational issue facilitated my development as a scholar. Becoming immersed in the evidence and citing relevant research studies has given me credibility

among the orthopedic surgeons and key stakeholders of the organization. Furthermore, the project provided a platform to incorporate DNP Essential III, Clinical Scholarship and Analytical Methods for Evidence-Based Practice, which holds competencies to evaluate quality improvement methodologies and the use of information technology to analyze data from practice (AACN, 2006). The competencies are evident through the evaluation of measuring VTE prophylaxis ordering adherence before and after implementation of the electronic order set. Designing a quality improvement methodology to assess ordering adherence has generated interest for orthopedic surgeons on their performance. The DNP project analyzed data from practice and patient outcomes by extracting data from the clinical information system and the electronic order set. The application of a scholarly approach to the DNP project will serve as the cornerstone for future quality improvement projects and research.

As Project Manager

The DNP project facilitated my growth as a project manager. In this capacity, I learned how to take a project from concept through the steps of planning, designing, implementation and evaluation. In order to stay on track with the project timeline, I have learned to develop detailed project plans with key mile stone dates. I have also learned that it is important to recognize that other project members may not have the same time line in mind and this requires negotiation and compromise to meet the project deliverables. The project supported DNP Essential IV, Information Systems/Technology and Patient Care Technology for the Improvement and Transformation of Health Care,

which holds competencies to extract data from clinical informatics systems and monitor outcomes of care (AACN, 2006). The project leveraged the clinical information embedded analytics system to analyze differences in VTE prophylaxis ordering adherence and orthopedic VTE outcomes. I learned that when data is presented in a meaningful way that validates if protocols are followed, the orthopedic surgeons took notice and wanted to know who the outliers were. I learned that every key stakeholder is important to the project's success. The project leader is responsible to regularly communicate the status of the project to key stakeholders. With the guidance of my mentor, I was successful in managing the project.

Summary

The purpose of the project was to assess the difference of orthopedic VTE occurrences in the post-operative THA patient before and after implementation of the electronic order set. Analysis of the results indicated that after the electronic order set was implemented, VTE occurrences decreased from 10 of 325 or 3.08% to 3 of 406 or .74%. This represents a decrease of 2.34% in VTE occurrences for the pre and postelectronic order set time periods. Mechanical prophylaxis ordering adherence of 100% was sustained both before and after the electronic order set was implemented. Pharmacological prophylaxis ordering adherence was increased by 2.7% from 86.5% to 89.2% after the electronic order set was implemented. Based on these findings, technology with standard electronic order sets has had a positive influence on ordering adherence and reducing VTE outcomes.

Completing the DNP project has been very rewarding and daunting. There were times when I was completely overwhelmed and wanted to give up. I questioned if I had enough intelligence, fortitude, patience, persistence, and tenacity to cross the finish line of the DNP program. I really struggled with writing the literature review portion of the paper. Deciphering the research studies was very challenging. I am glad that I persevered because I am able to discuss the evidence in a scholarly manner. I am grateful to Dr. Verklan for her guidance and support. Implementing conference calls every two weeks with Dr. Verklan kept me focused and on track. There were issues with the mapping of clinical data, which caused problems with data mining and extraction from the organization's electronic health record. The organization's CMIO was able to trouble shoot the mapping and remedy the issue. The lesson learned here is to expect the unexpected and be prepared for technological glitches because they will happen.

Overall, I am proud that I have made it to this point. Completing the DNP scholarly project will lay the foundation for future scholarly contributions to the nursing profession. It has inspired me to consider other projects for the orthopedic service line and preparing for the future of outpatient joint replacement. I am blessed with a wonderful family and network of close friends and colleagues that supported me and believed that I could become a Doctorate of Nursing Practice. I am looking forward to spending more time with my family and friends.

Section 5: Dissemination Plan

Nurses play a pivotal role in generating questions about safety and patient care. To improve patient care, it is necessary for nurses to develop advanced knowledge and skills to participate and lead teams that are pursuing best practices to improve patient care (Dearholt & Dang, 2012). Evidence-based practice and the nursing process are similar in that both are problem-solving strategies. As history has taught us, with innovation and major change come many challenges and golden opportunities for advancing nursing science, leadership, education, clinical practice and policy formulation, while optimizing organizational and nursing quality indicators, patient safety, and efficiency across systems of care (White & Dudley-Brown, 2012). Well-designed research and quality improvement projects provide one venue for showcasing the important contribution of nursing to major organizational change, improved quality, patient safety, efficiency, and overall effectiveness.

There is a significant need for nurses to disseminate the findings of their evidence to determine if a practice change is effective. My dissemination plan is to present the findings in a PowerPoint presentation to the hospital organization study site's orthopedic performance improvement team (PIT). The PIT team is a large interdisciplinary team comprised of organizational senior leaders, orthopedic surgeons, physician assistants, nurses, physical and occupational therapists, quality improvement specialists, discharge planners, pharmacists, and informatics nurses.

The next level of dissemination is to present a poster presentation at the organization's nursing day of inquiry. The nursing day of inquiry is an annual event that was developed to support nurses' translation of new scientific evidence into clinical practice. Nurses from across the health care system come together to share and disseminate the findings of their research and quality improvement projects.

Lastly, the next level of dissemination is to write a scholarly article for publication in a professional journal. At a later date, I will explore *Computers, Informatics and Nursing (CIN)* or *The Journal of Arthroplasty* as possible professional journals to publish in. A supplemental PowerPoint document will be provided, which details the plan to disseminate the scholarly work product.

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Appendix A: Venous Thromboembolism (VTE) Prophylaxis Data Collection Tool

A	B	C	D	E	F	G	H	I	J	K
Participant Number Assigned	**Admit Date**	**Discharge Date**	**Procedure Type**	**VTE During Admit**	**VTE Readmit 30 days**	**VTE Total**	**VTE Prophylaxis**	**Mechanical Prophylaxis**	**Pharmacological Prophylaxis**	**Both Mechanical & Pharmacological Prophylaxis**

Appendix B: Permission Plan Do Check Act

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Description of figure/table/extracts	Figure 1 Taylor, M. J., McNicholas, C., Nicolay, C., Darzi, A., Bell, D., & Reed, J. E. (2014). Systematic review of the application of the plan-do-study-act method to improve quality in healthcare. BMJ Quality and Safety, 23(4), 290-298. doi: 10.1136/bmjqs-2013-001862
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