Implementation and Evaluation of Electronic Prescribing for Preoperative Patients

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Abstract

Background: The adoption of health information technology (HIT) in the United States (US) is increasing due to government efforts to reform the healthcare system. Electronic prescribing (e-prescribing) is a type of HIT that enables prescribers to electronically transmit prescriptions directly and securely to pharmacies via certified and accredited software. Although the use of e-prescribing is rising, the Institute of Medicine's 2006 recommendation that all prescriptions be received electronically by 2010 has not been met.

Problem: The Procedure Readiness Evaluation and Preparation (PREP) center at the targeted site is staffed almost exclusively with advanced practice registered nurses (APRNs). Patients are provided preoperative evaluation and treatment. Mupirocin is the most commonly prescribed medication and is provided preoperatively to surgical cardiac, joint, and spine patients. Although an electronic health record (EHR) system with e-prescribing capabilities was implemented at the site in 2015, providers continued to use paper prescriptions. Thus, the purpose of this DNP scholarly project was to implement and evaluate e-prescribing within an ambulatory surgical preparation center at a large academic medical facility.

Methods: This 10 week quality improvement project included all APRNs (*N*= 7) at the PREP center. Prior to implementation, the project coordinator (PC) met with key organizational stakeholders to obtain support. Frontline staff was engaged. The PC attended several staff meetings during the months leading up to implementation and scheduled informal visits to build rapport and obtain end-user feedback. A site champion from the PREP center was selected to facilitate enhanced provider engagement. Through collaboration with the clinical informatics team, the cardiac, joint, and spine preoperative order sets were modified to contain the appropriate mupirocin regimen, allowing the APRNs to electronically prescribe from directly within each of the order sets. The APRNs were then thoroughly educated and e-prescribing was implemented at the site. During the final month of implementation, a retrospective chart review was completed to determine the number of preoperative cardiac, joint, and spine patients who received their mupirocin prescription electronically. At the conclusion of the project, all APRNs were invited to complete the System Usability Scale (SUS) survey to determine their perceptions of the usability of the e-prescribing system.

Results: All PREP center APRNs (*N*= 7, 100%) received education prior to initiating e-prescribing. During the final month, the APRNs were compliant with e-prescribing, electronically prescribing more than half of all mupirocin prescriptions (*n*= 33/53, 62%). All of the PREP center APRNs (*N*= 7, 100%) completed the post-implementation SUS survey and the mean score was 80.

Discussion: Sixty-two percent of prescriptions were transmitted electronically during the final month of implementation, which exceeded the goal of 50%. SUS survey results indicated that the providers felt that the e-prescribing system had a high degree of usability. Organizational support, selection of a project champion, and the positive attitudes among the APRNs, along with the EHR modification were crucial to the success of this project. This project is significant given that the utilization of HIT, including e-prescribing, has become a key feature in the US government's efforts to reform the healthcare system.

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Overview

The adoption of health information technology (HIT) in the United States (US) has steadily increased in recent years due to government efforts to reform the healthcare system (Jones, Rudin, Perry, & Shekelle, 2014). Health information technology encompasses a variety of technologies that have the ability to store, share, or analyze health information (Health IT.gov, 2013). Health care organizations continue to be offered incentives by the US government to increase the meaningful use of HIT in an effort to reduce costs and improve health outcomes (Zadeh & Tremblay, 2016). Electronic prescribing (e-prescribing) is a type of HIT that enables prescribers to electronically transmit prescriptions directly and securely to pharmacies via certified and accredited software (Hincapie, Warholak, Altyar, Snead, & Modisett, 2014). Computerized provider order entry (CPOE), often used alongside e-prescribing, refers to an electronic software system whereby clinicians can directly place orders via a computer (Agency for Healthcare Research & Quality (AHRQ), 2014). Electronic prescribing systems can either be standalone systems, or integrated within an electronic health record (EHR) and can have varying amounts of clinical decision support (CDS) features (Kannry, 2011). Clinical decision support provides practitioners timely information, ideally at the point of care, to help inform decisions about a patient's plan of care and includes tools such as standardized order sets (AHRQ, 2015). In 2014, 70% of physicians were utilizing e-prescribing in the US and 96% of pharmacies were able to accept electronic prescriptions (Hufstader & Swain, 2014). The percentage of physicians utilizing e-prescribing in Maryland during that same year was slightly below the national average at 67% (Hufstader & Swain, 2014). Although the use of e-prescribing in the US is rising, the

Institute of Medicine's (IOM) (2006) recommendation that all prescriptions be received electronically by 2010 has not been met (Jariwala, Holmes, Banahan, & McCaffrey, 2013).

Background

The Procedure Readiness Evaluation and Preparation (PREP) center at the targeted site is open Monday through Friday and staffed almost exclusively with advanced practice registered nurses (APRNs). Anesthesia medical residents also rotate through the center and provide direct patient care. Patients are provided comprehensive preoperative evaluation and treatment and providers coordinate care across a variety of specialties in order to ensure patients are medically optimized for surgery and anesthesia. Mupirocin, a topical antibacterial, is by far the most commonly prescribed medication at the PREP center. Mupirocin is provided preoperatively to all surgical cardiac, joint, and spine patients for decolonization purposes. Prior to this doctor of nursing practice (DNP) project, patients were provided a traditional paper prescription at the conclusion of their visit, which could then be filled at the patient's pharmacy of choice. Although an EHR system with e-prescribing capabilities was implemented at the site in 2015, providers had not changed their practice, and continued to use paper prescriptions; however, the APRNs did consistently document when a patient was provided a paper prescription for mupirocin. None of the providers at the PREP center were educated at the time of EHR implementation, and many were unaware that e-prescribing technology existed. Therefore, the purpose of this DNP scholarly project was to implement and evaluate e-prescribing within the ambulatory surgical preparation center at a large academic medical facility.

Electronic prescribing has been found to decrease costs, while increasing safety, satisfaction, and efficiency in healthcare (Fernando, Nguyen, Baraff, 2012; Jariwala et al., 2013; Porterfield, Engelbert, & Coustasse, 2014; Schleiden, Odukoya, & Chui, 2015; Qureshi et al., 2015). Despite known benefits of e-prescribing, barriers to universal adoption remain (Villasenor & Piscotty, 2016). Initial implementation costs and system maintenance, perceived inefficiencies and provider concerns, software malfunctions, and failure to properly plan and implement, whereby staff are not properly educated, rank among the top reasons for non-adoption (Mair et al., 2012; Marbury, 2015; Zadeh & Tremblay, 2016). All of these barriers combined lead to inconsistent and unpredictable prescribing practices (Villasenor & Piscotty, 2016).

For this DNP project, PREP center providers were thoroughly educated and e-prescribing was implemented in an effort to standardize the use of the EHR within the department. The cardiac, joint, and spine preoperative surgical order sets were modified to contain the appropriate mupirocin regimen in order to help providers quickly and accurately prescribe using the EHR. Recent literature has found that thorough provider training and customization of e-prescribing features are critical to facilitate safe conditions whereby both patients and providers are satisfied (Cochran et al., 2013; Hincapie et al., 2014; Matthews et al., 2013). The primary anticipated outcome of this project was increased provider utilization of e-prescribing, as evidenced by having at least 50% of mupirocin prescriptions sent electronically (Centers for Medicare & Medicaid Services (CMS), n.d.). Secondarily, provider perception of the usability of the e-prescribing system was evaluated post-implementation via the System Usability Scale (SUS) survey. It was postulated that if providers had a more favorable perception of the e-prescribing system that they would be more likely to electronically transmit patient prescriptions.

Significance

This DNP project is significant given that the majority of prescriptions are written in the ambulatory care setting where medication errors are common (Abramson, Barron, Quaresimo, & Kaushal, 2011). Additionally, Surescripts (2012), one of the nation's largest health information networks, reported that e-prescribing has the potential to save the US between $140 billion and $240 billion in healthcare costs over the next decade. However, most notably, the US government is now requiring the adoption of HIT, such as e-prescribing, through various legislative efforts (Villasenor & Piscotty, 2016).

The Health Information Technology for Economic and Clinical Health (HITECH) Act was enacted in 2009 as part of the larger American Recovery and Reinvestment (ARRA) Act (Centers for Disease Control and Prevention (CDC), 2017). The ARRA Act was a large stimulus package that included measures to modernize the nation's infrastructure, while the HITECH Act specifically aimed to enhance the meaningful use of EHRs, in conjunction with efforts led by the CMS and the Office of the National Coordinator for Health Information Technology (CDC, 2017). Meaningful use is the use of certified EHR technology in a meaningful manor whereby there is an electronic exchange of health information, with the overall goal of improving the quality of care (CDC, 2017).

Following the promulgation of the HITECH Act, the CMS granted incentive payments to eligible professionals (EPs) and eligible hospitals (EHs) that could demonstrate they had engaged in efforts to adopt, implement, or upgrade certified EHR technology (CDC, 2017). While participation in the CMS incentive program is voluntary, those EPs and EHs who failed to join by 2015 will notice negative adjustments on their CMS fees, with a 3% reduction having begun in 2017 (CDC, 2017). As part of this program, the CMS require EPs and EHs to accomplish specific meaningful use objectives. Electronic prescribing is one way to attest to meaningful use, and in order to avoid financial loss, EPs and EHs are required to reach increasing goals per the CMS guidelines (P. Thompson, personal communication, February 24, 2016). As of 2017, all EPs must electronically prescribe at least 50% or more of permissible prescriptions and for EHs, more than 10% of hospital discharge medication orders for permissible prescriptions must be electronically prescribed (CMS, n.d.).

Theoretical Framework

The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care provided the theoretical structure needed for this DNP project and was operationalized in order to address the identified problem and support the proposed interventions (see Figure 1). The model was first developed in 1994 to help healthcare providers utilize research for the improvement of patient care (Titler et al., 1994). It has been revised several times, most recently in 2015, and continues to offer a pragmatic approach for those integrating evidence into practice (Titler et al., 2001; University of Iowa Hospitals and Clinics, 2015). The model begins with the identification of a problem, and then a stated purpose or question. There are three decision points along the model where it is determined if the identified problem is a priority topic, if there is sufficient evidence, and if change is appropriate for adoption into practice. For this project, the lack of provider utilization of e-prescribing in the PREP center was identified as a priority topic given the national initiative to enhance HIT utilization and the unfolding CMS regulations. The evidence to support its use in practice was presented, and the practice change was implemented and evaluated. Key personnel were engaged, while resources and constraints were reviewed and a plan for full implementation was created. Education materials were developed as learning tools for clinicians, and the project coordinator (PC) reviewed the e-prescribing process with providers to facilitate and ensure adoption. Collection of post-implementation data involved retrospective chart reviews to determine provider use of e-prescribing. Data analysis allowed the PC to ascertain whether practice change was successfully implemented. Results were then disseminated at the PREP center.

Literature Review

Given the increasing rate at which HIT is incentivized and implemented throughout the US healthcare system, this literature review presents evidence to support the use of e-prescribing (see Appendix A for strength and quality of evidence). The data to support the adoption of e-prescribing centers primarily around improved patient safety; therefore, evidence which shows decreased medication errors and adverse drug events (ADE) will be presented first, followed by research displaying improved health outcomes.

Three research studies and three systematic reviews displaying improved patient safety through the use of e-prescribing will be discussed. Abramson et al. (2011) utilized a prospective, nonrandomized pre-post design with concurrent controls to assess the effect of an e-prescribing system with CDS on the rates of ambulatory prescribing errors throughout several primary care practices in New York. Of the six providers who adopted e-prescribing, compared to the 15 who continued paper prescribing, error rates for e-prescribers were significantly lower than for paper prescribers at one year ($p<.001$). Similarly, Devine et al. (2010) utilized a quasi-experimental pre-post design to evaluate the effects of a basic CPOE system on medication errors and associated ADE within a community based multi-specialty practice in Washington. Investigators compared 5,016 handwritten prescriptions at baseline to 5,153 electronic prescriptions post-implementation and found a statistically significant reduction in medication errors from 18.2% to 8.2%, which equals a reduction in adjusted odds of 70% (Odds ratio (OR)= 0.30; $p<.001$). There was also a 57% reduction in adjusted odds for potential ADEs (OR= 0.43; $p<.001$). Likewise, Westbrook et al. (2012) conducted a before-after study at two major teaching hospitals in Australia. Hospital A implemented e-prescribing on one ward, while three wards served as concurrent controls; in Hospital B, e-prescribing was implemented on two wards and compared before and after. Researchers compared 1,923 paper prescriptions at baseline to 1,368 electronic prescriptions at follow-up. All intervention wards saw a statistically significant reduction in medication errors, ranging between 57.5% and 66.1%. At Hospital A, error rates decreased from 6.25 per admission at baseline to 2.12 post-intervention ($p<.0001$) and at Hospital B, error rates decreased from 3.62 per admission at baseline to 1.46 post-intervention ($p<.0001$).

All researchers utilized convenience samples from single geographic regions, potentially limiting generalizability; however, all of the studies were conducted at multiple practice sites, enhancing external validity (Abramson et al., 2011; Devine et al., 2010; Westbrook et al., 2012). While Abramson et al. (2011) utilized a small sample size, Devine et al. (2010) included 242 providers in their study. Devine et al. (2010) and Westbrook et al. (2012) evaluated prescriptions from multiple provider specialties, while Abramson et al. (2011) only utilized adult primary care providers. Abramson et al. (2011) and Devine et al. (2010) conducted their studies in ambulatory, non-academic affiliated community practices, while Westbrook et al. (2012) conducted their study at two large academic affiliated inpatient facilities. None of the studies utilized a randomized design; however, Abramson et al. (2011) and Westbrook et al. (2012) did have concurrent controls, enhancing internal validity. All researchers allowed for some amount of lag time following e-prescribing implementation, in order to promote routine stability. Abramson et al. (2011) noted that providers in their study were aware that their prescriptions were being monitored, which may have affected the results, and Devine et al. (2010) only evaluated prescriptions that were filled at the clinic owned pharmacies. Furthermore, Westbrook at el. (2012) noted that even after e-prescribing implementation, certain medications were still ordered via a paper-based method, potentially affecting validity. Researchers from all of the studies established inter-rater reliability for data collectors. The CDS features embedded within the e-prescribing systems varied throughout each of the studies, potentially weakening generalizability. Study methodology, medication error terminology, and classification differed among researchers, making comparisons difficult. After reviewing all of the studies, decreased medication errors were noted throughout, while some researchers also found decreased ADE.

On a larger scale, Ammenwerth, Inderst, Machan, & Siebert (2008) and Radley et al. (2013) conducted systematic reviews to quantify the degree to which e-prescribing reduced medication errors. Moreover, Nuckols et al. (2014) performed a systematic review and meta-analysis to assess the effectiveness of CPOE at reducing preventable ADEs in the hospital setting. Ammenwerth et al. (2008) analyzed 27 studies to assess the effect of e-prescribing on the risk of medication errors and ADE. To detect medication error and ADE rates, investigators utilized the definitions provided by each of the authors in each of the studies. Researchers found a significant relative risk reduction (RRR) in medication errors between 13% and 99% for those providers who utilized e-prescribing systems. A RRR in ADE between 30% and 85% was also appreciated, as was a reduction in potential ADE of 35% to 98%. During sub-group analysis, studies comparing handwritten prescriptions with electronic prescriptions showed a higher RRR in errors, than in other comparison groups. Moreover, Radley et al. (2013) utilized meta-analytic techniques to estimate the number of medication errors that are averted in US hospitals due to provider use of CPOE systems. The final sample included 4,701 hospitals and researchers noted that processing an order through a CPOE system decreased the likelihood of a medication order error by 48% (95% confidence interval (CI): 41%-55%). Based on the researchers' calculated effect size and the number of hospitals in the US in 2008 that were utilizing CPOE systems, investigators estimated a 12.5% reduction in medication errors, or about 17.4 million averted medication errors in one year (Radley et al., 2013). Similarly, Nuckols et al. (2014) analyzed 16 studies and utilized random effects models to pool data in order to assess the effectiveness of CPOE at reducing preventable ADEs in the hospital setting. Studies were eligible for inclusion only if they compared CPOE methods with paper-order entry in acute care facilities and were excluded if researchers utilized limited event-detection methods. Authors focused more heavily on medication errors involving a relatively higher risk; therefore, studies that reported on errors involving little to no potential for harm were excluded. Researchers found that when compared to paper-order entry, CPOE systems were associated with half as many preventable ADEs (pooled risk ratio (RR)= 0.47, 95% CI: 0.31-0.71) and medication errors (RR= 0.46, 95% CI: 0.35-0.60).

All three of these studies concluded that e-prescribing significantly reduced medication errors and/or preventable ADEs (Ammenwerth et al., 2008; Nuckols et al., 2014; Radley et al., 2013). They each used large sample sizes, enhancing generalizability. Ammenwerth et al. (2008) captured some of the earliest studies about e-prescribing and patient safety. Inclusion and exclusion criteria were all well explained and were broad enough to capture a variety of patient care groups throughout diverse settings. All researchers noted that the majority of included studies were conducted at large academic institutions in adult inpatient units, potentially limiting generalizability (Ammenwerth et al., 2008; Nuckols et al., 2014; Radley et al., 2013). Differing types of e-prescribing systems with varying amounts of CDS features were included, and all authors noted the significant amount of heterogeneity between study designs and methodological rigor.

Michelis et al. (2011) conducted a retrospective cohort study to determine if e-prescribing with formulary decision support (FDS) was associated with an improved ability for patients to attain their cholesterol goals. Formulary decision support provides prescribers information about drug costs. Investigators queried 2,218 EHRs from patients in a multi-specialty outpatient academic medical practice in Washington, DC. Researchers found that patients receiving an electronic prescription were 59% more likely to achieve their cholesterol goals than patients who received a paper prescription (OR: 1.59, 95% CI: 1.12-2.25). Authors speculated that this was likely due to patients receiving lower cost medications, since patients with an electronic prescription were more likely to receive a generic statin than those who received a paper prescription (p=.0004). Given the non-randomized design and convenience sample from one clinical site, generalizability is limited; however, the study was well designed, study groups were similar at baseline, and researchers utilized a sufficient sample size. While inferences can be made from these results, more research is needed to link e-prescribing with improved patient outcomes.

Clearly, the literature shows that e-prescribing is associated with decreased medication errors and ADE (Abramson et al., 2011; Ammenwerth et al., 2008; Devine et al., 2010; Nuckols et al., 2014; Radley et al., 2013; Westbrook et al., 2012). Additionally, e-prescribing with FDS was found to enhance patients' ability to attain their cholesterol goals (Michelis et al., 2011). The reviewed studies have been conducted in a variety of geographic settings and medical specialties. While there is considerable variation in the types of e-prescribing systems that clinicians utilize, the research discussed here captured many of the current nuances. Overall, more randomized control trials and systematic reviews compiling studies that utilize similar terminology and methodologies would be beneficial. Studies determining the most beneficial types of CPOE and e-prescribing systems should also be completed. Current evidence regarding the ability of e-prescribing to reduce patient morbidity and mortality is sparse. Despite gaps in evidence and new data displaying the unintended errors CPOE can introduce, e-prescribing is an essential component of meaningful use and is necessary in order for healthcare professionals to avoid financial penalties (AHRQ, 2014; CMS, n.d.).

Methods

Study Design, Sample, and Setting

This quality improvement (QI) project was conducted at a large academic medical facility located in the mid-Atlantic region in the US. The sample for this project was all full-time, part-time, and per diem APRNs (N= 7) working in the PREP center. An EHR system with e-prescribing capabilities was previously made available at the targeted site, providing e-prescribing access to all APRNs at the PREP center. The APRNs were asked to electronically prescribe the preoperative mupirocin prescription for patients undergoing cardiac, joint, and spine surgical procedures during the ten-week implementation period (September 1, 2016-November 15, 2016). The University of Maryland Baltimore Institutional Review Board approved this project as non-human subjects' research and no further permissions or consents were required (see Appendix D).

Procedures

During the pre-implementation phase of this project, the PC met with select key organizational stakeholders, such as the director of quality and safety and the director of infection prevention and hospital epidemiology, to obtain support, discuss resources and constraints, as well as project significance and sustainability. In order to engage frontline staff, the PC also attended several staff meetings in the months leading up to implementation, as well scheduling informal visits, in an effort to discuss project goals and significance and to alleviate any concerns at the point of care and ensure changes enhanced practitioner workflow. A site champion from the PREP center was selected to facilitate enhanced provider engagement and adoption. Support from the clinical informatics team was also critical, as the cardiac, joint, and spine surgical order sets required modification, whereby the appropriate mupirocin regimen became embedded within the order sets. This step was essential to ensure project sustainability, as well as ensuring the accurate and efficient electronic transmission of patient prescriptions by allowing the APRNs to electronically prescribe from directly within each of the order sets. The PC also discussed the QI project with the PREP center medical director to obtain support and the necessary approvals to modify the selected order sets.

In the two weeks prior to e-prescribing implementation (August 15, 2016- August 31, 2016), the PC provided education to each of the PREP center APRNs via a PowerPoint presentation, which was sent through e-mail, and by face-to-face contact during the August staff meeting. The QI project goals were stated and the benefits and significance of e-prescribing were discussed. The PC provided the APRNs a comprehensive review on how to successfully transmit a prescription electronically. The PC's goal was to provide 100% of the PREP center APRNs with the in-service education prior to e-prescribing implementation.

This QI project was implemented for ten weeks (September 1, 2016- November 15, 2016). At the start of implementation, the PC distributed laminated reference sheets to all PREP center APRNs, serving as a step-by-step guide for e-prescribing within the EHR system. Extra reference sheets were also stored in the APRN office at the PREP center. Furthermore, signs were placed on each of the computers in all of the PREP center examination rooms, and throughout highly trafficked areas in the PREP center in order to remind and encourage providers to e-prescribe. A reminder e-mail was sent to all APRNs on the first day of implementation, instructing providers to electronically prescribe the preoperative mupirocin prescription for all eligible patients during their PREP center visit. The APRNs were informed that they had to verify the patient's pharmacy of choice prior to electronic transmission and while it was ultimately the patient's choice regarding which pharmacy they selected, the providers were encouraged to ask patients at the start of their visit if they wanted their prescription sent to the hospital's ambulatory pharmacy, which is located next to the PREP center. The goal was to have at least 50% or more of the ordered prescriptions sent electronically (CMS, n.d.).

Throughout this QI project, the PC conducted weekly needs assessments, monitoring for concerns or difficulties with e-prescribing, monitored aggregate data, and re-educated staff as needed. Weekly updates were communicated to all APRNs via either e-mail or face-to-face interaction. Perceived and encountered barriers were continually assessed via e-mail and face-to-face contact in order to facilitate usability and the adoption of e-prescribing. No individual provider or patient data was collected. See Appendix B for the detailed implementation plan and QI project timeline.

Data Collection

Prior to e-prescribing implementation, the number of APRNs who received education was recorded. Following the ten-week implementation period, a retrospective chart review was conducted to assess e-prescribing compliance among APRNs during the final month of implementation (October 15, 2016 - November 15, 2016). The purpose of the chart review was to determine the percentage of electronically transmitted mupirocin prescriptions for surgical patients undergoing cardiac, joint, and spine procedures. Individual provider or patient data was not collected.

At the conclusion of the ten-week implementation period, all PREP center APRNs were asked to complete the SUS survey to evaluate their perceptions of the usability of the e-prescribing system. Completion was voluntary and all results were kept anonymous. No demographic data was collected from survey participants. The project champion distributed paper copies of the survey to all interested APRNs. Completed surveys were then collected by the project champion and sent to the PC. See Appendix C for the detailed data collection plan.

Instruments

The SUS survey, developed in 1986 is used as a quick measure to assess an individual's perception of usability for a given product or service (Bangor, Kortum, & Miller, 2008; Brooke, 2013). Usability is operationally defined as an individual's subjective perception of interaction with a system (Brooke, 1996). The SUS is a versatile tool that has been used extensively for almost 30 years and has been deemed both reliable and valid, even with small sample sizes (Brooke, 2013; Bangor et al., 2008). Reliability for the tool was reported using Cronbach's alpha and noted to be 0.91 (Bangor et al., 2008). The SUS survey consists of ten questions, scored on a standard five-item Likert scale, ranging from strongly disagree to strongly agree (see Appendix E). Total raw scores range from 0 to 40; however, for odd number items, the researcher must subtract one from the users response and for even numbered items, the researcher must subtract the users response from five (Sauro, 2011). The converted responses are then added together and multiplied by 2.5 to produce a final score ranging from 0 to 100 (Sauro, 2011). Higher scores indicate a higher usability rating (Kortum & Peres, 2014). Products should have scores above 70, with ideal products scoring in the high 70s to upper 80s, and superior products scoring better than 90 (Bangor et al., 2008). Products scoring less than 70 should be scrutinized (Bangor et al., 2008). The SUS survey is nonproprietary and its use is permitted for non-commercial, academic purposes without prior permission (Bangor et al., 2008; Brooke, 2013).

Data Analysis

All descriptive analyses were performed using Microsoft Excel software. The number of APRNs who received education was analyzed with descriptive statistics, noting frequencies and percentages. Electronic prescribing rates among APRNs were calculated during the final month of implementation to determine the number of preoperative cardiac, joint, and spine patients who received their mupirocin prescription electronically. Descriptive statistics were utilized to document total and weekly frequencies and percentages. Weekly averages were then calculated and aggregated to determine the overall mean and standard deviation. Provider results from the SUS survey were analyzed per standard SUS methodology, while descriptive statistics were used to calculate the mean and standard deviation. QI project results were sent to all APRNs at the PREP center in January 2017.

Results

E-prescribing

All of the PREP center APRNs (N= 7, 100%) received education prior to e-prescribing implementation. The rates of e-prescribing compliance among APRNs were assessed each week during the final month of implementation (see Table 1). See Figure 2, which compares the number of patients who did and did not receive an electronic prescription during the final month of implementation. During this same time, weekly analysis revealed that the rates of e-prescribing among APRNs progressively increased as the QI project moved forward (see Figure 3). Overall, during the final month of implementation, the APRNs were generally compliant with e-prescribing, electronically prescribing more than half of all mupirocin prescriptions (n= 33/53, 62%) (see Figure 4).

Usability

The post-implementation SUS survey was completed by all of the PREP center APRNs (*N*= 7, 100%). The mean SUS survey score was 80, with a standard deviation of 11. Scores ranged from 67.5 to 100. See Figure 5 to visualize the distribution of provider scores.

Discussion

The purpose of this DNP project was to implement and evaluate e-prescribing within an ambulatory surgical preparation center by having the APRNs electronically prescribe cardiac, joint, and spine patients their preoperative mupirocin prescription. Electronic prescribing was successfully implemented among the APRNs, as evidenced by having over 60% of prescriptions transmitted electronically, which exceeded the goal of 50%. The PC collected post-implementation data during the final month to allow for routine stability, which is consistent with other researchers (Abramson et al., 2011; Devine et al., 2010; Westbrook et al., 2012). While provider time and commitment required in the early phases of adoption is considerable, this is often a temporary finding and providers typically report enhanced efficiency post-implementation (Gagnon, Nsangou, Gagnon, Grenier, & Sicotte, 2014).

According to the SUS survey, which was completed by all of the APRNs, results indicated that the providers felt that the e-prescribing system had a high degree of usability, as the average was noted to be 80 (Bangor et al., 2008). Provider perception, including perceived usefulness and ease of use, is a huge component when implementing e-prescribing (Gagnon et al., 2014). A perceived lack of self-efficacy, poor familiarly with technology, and uncertainty of outcomes can become significant barriers to e-prescribing adoption (Gagnon et al., 2014). Although this QI project was underpowered to report on statistically significant results or relationships, researchers have found that user satisfaction with e-prescribing systems can lead directly to continuous usage (Sutherland & Heuvel, 2002). Moreover, researchers have found changes in users perception between the pre and post implementation phases, as perceptions become more favorable with more frequent use of e-prescribing (Gagnon et al., 2014). Jariwala et al. (2013) have substantiated these claims by noting the linear relationship found between the stage of e-prescribing adoption and the perception of how encouraging or discouraging providers perceived e-prescribing factors.

Implications

Utilization of HIT, including e-prescribing, has become a key feature in the US government's efforts to reduce costs and improve health outcomes (Jones et al., 2014; Zadeh & Tremblay, 2016). The federal government has been encouraging e-prescribing for over a decade now and the IOM's (2001) report entitled *Crossing the Quality Chasm* called for the transformation of healthcare through the use of HIT, including the use of e-prescribing (Gabriel, Furukawa, & Vaidya, 2013). Moreover, the meaningful use of interoperable electronic health information throughout the US healthcare system is a critical national priority (CDC, 2017). Electronic prescribing is one way to attest to meaningful use and compliance with all CMS issued objectives is critical in order for EPs and EHs to avoid financial loss (CDC, 2017; CMS, n.d.).

Many of the US government's legislative efforts, including the HITECH Act, have been created to meet the Institute for Healthcare Improvement's (IHI) triple aim, which consists of: improving patient care, improving population health, and reducing healthcare costs (IHI, n.d.). While data displaying improved health outcomes is sparse, recent literature has found that e-prescribing is associated with decreased medication errors and ADEs (Nuckols et al., 2014). Although research is scant, preliminary findings have also displayed some financial benefit to the use of e-prescribing (Ahmed, Barber, Jani, Garfield, & Franklin, 2016; Forrester, Heep, Roth, Wirtz, & Devine, 2014; O'Reilly, Tarride, Goeree, Lokker, & McKibbon, 2012; Westbrook et al., 2015).

Implementation Strategies

The Iowa Model (see Figure 1) provided the theoretical framework needed to ensure project success and sustainability. The PC considered the evidence, environment, barriers, and enablers as a means to promote the successful integration and adoption of e-prescribing (Legare & Zhang, 2013). Evidence suggests increased success when implementation strategies are tailored to specific barriers and enablers (Ritchie, 2013). During the pre-implementation phase, the PC conducted workflow analyses at the PREP center to have a thorough understanding of existing local processes before implementation strategies were designed (Cresswell, Bates, & Sheikh, 2013). Site-specific resources, constraints, and approvals were all considered prior to implementation and based off of these determinants, the PC drafted a comprehensive implementation and evaluation plan, including a detailed project timeline. Having a project lead, such as the PC, to extensively manage all aspects of implementation has been cited as one aspect to facilitating e-prescribing adoption (Nuckols et al., 2014). It is well known that if poorly designed or implemented, that HIT systems can pose significant risk to patient safety (Odukoya & Chui, 2013; Zadeh & Tremblay, 2016). Thus, having a strategic plan to implement e-prescribing has been cited as a critical component in facilitating adoption (Gagnon et al., 2014).

Selecting a relevant issue, such as e-prescribing, was necessary in order to gain buy-in from key organizational stakeholders and front line staff. As previously stated, e-prescribing is a national initiative and CMS priority, making it an ideal subject matter. Furthermore, the PC assembled, appraised, and synthesized a robust body of evidence that could substantiate the project proposal. Given the amount and compelling nature of the evidence, the PC then identified the individuals that would need to be included in order to successfully implement and sustain this QI project.

Organizational readiness, including buy-in from key stakeholders, is needed to facilitate commitment during large scale HIT initiatives (Cresswell et al., 2013; Gagnon et al., 2014). The PC utilized the stakeholder mapping matrix based on Gambles (2009) model in order to identify, classify, prioritize, and integrate the appropriate individuals into the project plan (Shirley, 2012). The PC followed the seven principles of stakeholder management proposed by Clarkson (1995) and included the following actions: acknowledging and actively monitoring the concerns of all stakeholders, listening and openly communicating with the stakeholders about their concerns, adopting processes and behaviors that were sensitive to stakeholders concerns, recognizing the interdependence among stakeholders, working cooperatively with others to minimize risk and harm, avoiding activities that could potentially jeopardize relationships with stakeholders, and acknowledging the potential conflicts between stakeholders, while employing open communication strategies to address any such conflict.

The implementation and maintenance of e-prescribing systems consumes a considerable amount of resources; thus, the culture should fully embody the change prior to project initiation (Gagnon et al., 2014). The perception of organizational support, including adequate resource allocation, is needed when adoption among front line staff members is expected (Legare & Zhang, 2013). This QI project was supported and approved by organizational leaders, such as the medical director for the PREP center and the institution’s director of quality and safety, and the PREP center APRNs, which is needed when attempting to build consensus and support practice change (Cresswell et al., 2013). Likely the largest enabler was that an e-prescribing system was already in place at the site and situated within the EHR system, which is critical given the initial expenses associated with e-prescribing systems. There was also sufficient infrastructure to support e-prescribing use, such that functional computers were available in the APRN office and in all patient rooms and there was an adequate wireless network, which are important features to promote use of e-prescribing systems (Cresswell et al., 2013).

Prior to implementation, clinicians were prepared and materials were created for their learning. Organizations should put emphasis on education and training during the pre-implementation phase to ensure an easier transition, as trained users tend to be more satisfied with new HIT systems (Creswell et al., 2013; Fuchs, Lo, Peterman, Camp, & Chase, 2016; Gagnon et al., 2014). To further enhance adoption, aspects from adult learning theories were employed, as the APRNs were provided a clear rationale for the project including project goals and objectives (Palis & Quiros, 2014). Concerns regarding patient safety, privacy and security, as well as skepticism about the benefits and significance of e-prescribing are common barriers to adoption; thus, each of these topics was covered (Gagnon et al., 2014). The content was relevant to each practitioner's practice, and could be readily applied in the clinical setting (Palis & Quiros, 2014). Education was interactive, tailored to the clinician's role and familiarity with technology, and done close to the time of implementation (Cresswell et al., 2013). Cresswell et al. (2013) discussed the differences in users comfort level with available HIT systems, such that some users require more education than others. Reeducation was also provided to staff on an as needed basis, which is ideal for sustainability (Crosson et al., 2011). Additionally, tip sheets were provided to the APRNs, which Fuchs et al. (2016) has also found to be beneficial. Fortunately, this site had a small number of providers; hence, the implementation process was more intimate and interactive, allowing for individualized education, which can be advantageous (Cresswell et al., 2013).

Another critical aspect to the success of this QI project was that the PC maintained constant and open communication, via e-mail and face-to-face contact, with the APRNs and relevant stakeholders to provide progress updates and to ensure adequate momentum, which is needed for successful implementation (Cresswell et al., 2013; Fuchs et al., 2016). Reflection on successes and failures is crucial, as is maintaining flexibility and open lines of communication (Cresswell et al., 2013). This was especially necessary during times were barriers and unforeseen events arose; for example, when several of the APRNs were awaiting authorization to electronically prescribe. The PC continually sought input from the APRNs to understand the contextual determinates of their practice and in an effort to ensure that change would only enhance their practice. Participation of end-users in the implantation processes has been found to be critical (Fuchs et al., 2016; Gagnon et al., 2014). Likewise, Cresswell et al. (2013) reiterate the importance of capturing user feedback regarding problems and responding in a timely manner to mitigate issues. For example, many of the APRNs found they did not have the necessary authorization to electronically prescribe; therefore, the PC took on the responsibility of communicating with the clinical informatics team to follow through on issues affecting the APRNs ability to adopt this practice change. Moreover, many of the APRNs reported concerns about whether electronically transmitted patient prescriptions were being received by the patient's intended pharmacy; thus, to alleviate concern, the PC audited eligible patient charts and called the pharmacy to confirm receipt. The APRNs' concerns corresponded to research conducted by Gagnon et al. (2014), who cite interoperability concerns as a common barrier to adoption. Similarly, providers, including the APRNs in this study, often report concerns about pharmacies ability to accept electronic prescriptions (Gagnon et al., 2014). Gagnon et al. (2014) recommend that organizations provide adequate, ongoing support and emphasize interdisciplinary collaboration. The benefits of major HIT initiatives take time to materialize and expectations need to be realistic to maintain engagement, as a result, the PC was transparent with staff regarding expectations and progress (Cresswell et al., 2013).

Of no less importance, was the monumental role that the project champion assumed in promoting the integration of e-prescribing within the PREP center (Crosson et al., 2011; Ritchie, 2013). Additionally, the lead APRN reported familiarity with e-prescribing; thus, to leverage these enablers, the PC worked especially close with these practitioners. A crucial part to the successful implementation of large scale HIT initiatives is strong leadership support (Cresswell et al., 2013). Having leaders that are visible and inclusive is ideal for creating a culture that supports innovation (Cresswell et al., 2013; Gagnon et al., 2014). In conjunction with the PC, the project champion and lead APRN were also strong advocates for the project and assisted other staff members learn and integrate e-prescribing into their routines. This was even more critical because the PC did not work at the institution; however, the PC prioritized building rapport with staff and relevant stakeholders early in the QI project. While some providers voiced concerns about e-prescribing, the majority of providers were receptive, as evidenced by their positive attitudes. Positive attitudes and provider agreement with e-prescribing have been found to be a common facilitator for adoption; contrarily, resistance to change, especially when providers see no added benefit to e-prescribing, can lead to abandonment of technology (Gagnon et al., 2014). Overall, the affirmative demeanors among the APRNs, as well as their exceptionally collegial relationships with one another, afforded them the ability to work through initial obstacles. Staff was respectful towards one another and effectively collaborated, which is vital for implementation (Cresswell et al., 2013; Gagnon et al., 2014).

Finally, when practice change is deemed appropriate for adoption into practice, the change should be hardwired into the existing system. Hence, as a means to integrate and sustain e-prescribing within the PREP center, the cardiac, joint, and spine preoperative surgical order sets were modified to include the appropriate mupirocin regimen, effectively allowing the APRNs to electronically prescribe from directly within the order sets. Customizing e-prescribing systems to meet provider needs is a reasonable maneuver to promote adoption, wherein the system is pragmatic for end-users (Cresswell et al., 2013; Fuchs et al., 2016; Hincapie et al., 2014). Of importance, the institution's clinical informatics team was also willing to modify the order sets to facilitate enhanced provider use, which has been found to improve patient outcomes (Matthews et al., 2013). Health information technology systems should not only fit the organization, but should also fit clinical practice (Cresswell et al., 2013). Poor system design can make it difficult for providers to integrate e-prescribing into their daily routines; therefore, meeting provider expectations is essential (Abramson et al., 2012; Zadeh & Tremblay, 2016). Providers report wanting a functional, accessible, and supported e-prescribing system that responds to their professional needs (Gagnon et al., 2014).

Limitations and Lessons Learned

Despite the overall success of this QI project, there were several limitations worth mentioning. The overall sample size (N=7) was small and comprised only of APRNs, limiting external validity. Furthermore, given the nature of practice at the targeted site, the PC only collected data for a specific patient population and for one specific medication, threating generalizability and extrapolation of findings into other care areas.

This QI project was slow to gain momentum given that several of the APRNs were unauthorized to electronically prescribe medications, despite what the PC initially believed to be true. An inquiry was submitted to the clinical informatics department and it took several weeks for this issue to be resolved and one of the APRNs in particular, was not granted access until the end of the project. Technical concerns are one of the most commonly reported barriers to e-prescribing implementation; therefore, the PC should have ensured each practitioner had the necessary access to electronically prescribe (Gagnon et al., 2014).

Among other unforeseen events, was the limited amount of space in the *sig* section of the electronic prescription, limiting the amount of instruction that the APRNs could provide their patients. Providers were concerned that patients would not receive enough detail to accurately use their mupirocin prescription. This corresponds with findings from Gagnon et al. (2014) regarding the barriers to e-prescribing implementation, as design limitations are noted to be a common impediment to e-prescribing utilization. Thus, the PC arranged to have the after-visit summary (AVS) template modified, whereby the APRNs could place detailed mupirocin directions for their patients. The AVS is a meaningful use element already instituted at the PREP center and is provided to each patient at the conclusion of their visit and contains relevant actionable information and instructions for patients (Hummel & Evans, 2012).

In addition, the order set which is utilized for surgical spine patients took longer than expected to modify, forcing the APRNs to create workarounds to continue e-prescribing. This practice was not ideal considering the intention of e-prescribing is to enhance safety and efficiency. As is well reported in the literature, EHR system malfunctions were reported by the APRNs on a few occasions, predictably causing reduced compliance with e-prescribing. When providers encounter problems with e-prescribing systems, they often revert back to paper prescriptions to limit workflow interruptions, which occurred in this QI project (Zadeh & Tremblay, 2016). System reliability and dependability are common concerns among providers and appear to be well founded (Gagnon et al., 2014). Many of the presented barriers are presumably related to the fact that the EHR system at the targeted site was undergoing a major software upgrade during the early phases of this QI project, potentially increasing the time it took to resolve information technology (IT) issues. Robust IT support has been cited as a necessary component during implementation (Crosson et al., 2011).

Finally, this QI project did not track the actual rate of medication errors or ADE in the PREP center pre or post implementation, nor was the rate of mupirocin compliance assessed, which may have strengthened the validity of e-prescribing. Future considerations could include tracking the rate of mupirocin compliance when e-prescribing is utilized. Furthermore, there is a continuous rotation of anesthesia residents through the PREP center and while they were not included in this QI project, their prescribing practices should be investigated in order to standardize patient care throughout the PREP center. Likewise, there is a noticeable amount of disconnect between the surgeons' outpatient offices and the PREP center providers, wherein some patients receive preoperative medications and supplies by their surgeon and others receiving items at the PREP center, which has created frustration among PREP center APRNs. To enhance the continuity of patient care, future QI projects should be undertaken at this site to establish evidence-based, standardized pathways articulating the ideal trajectory of care for patients requiring surgery, specifically noting who should be seen in the PREP center and who should receive preoperative mupirocin.

Conclusion

With *The Iowa Model* providing the theoretical framework, the author of this QI project has successfully implemented e-prescribing within an ambulatory surgical preparation center; furthermore, the APRNs reported that the e-prescribing system had a high degree of usability in this setting. Initially, the PC had to identify a priority topic and since the meaningful use of HIT is a national initiative and continues to be incentivized by the US government to help reduce costs and improve health outcomes, e-prescribing was determined to be an ideal subject matter. Secondly, the PC had to assemble, appraise, and synthesize a body of evidence to support the implementation and use of e-prescribing. Electronic prescribing and CPOE were found to be associated with decreased medication errors and ADEs. However, more studies are needed to identify and optimize the benefits of e-prescribing systems, while minimizing unintended consequences. Likewise, more studies are needed to link e-prescribing with reduced patient morbidity and mortality. In the third phase, the PC designed the implementation and evaluation plan. After conducting workflow analyses at the PREP center and considering site-specific barriers, enablers, and necessary approvals, a strategic plan was then developed. Within this phase, the PC secured stakeholder buy-in, selected a devoted project champion, and ensured that the APRNs were well educated regarding the electronic transmission of patient prescriptions. Collaborative interaction with end-users is needed to optimize technological design, which can facilitate enhanced efficiency and effectiveness; thus, the PC made continued collaboration a priority. Finally, in the fourth phase, the PC integrated and sustained the practice change within the PREP center. Continued support from the project champion and the lead APRN will be needed and by incorporating end-user feedback into the project design, e-prescribing was nicely integrated into each of the practitioners daily routine. One of the most critical features was hardwiring change into the existing EHR system by modifying the preoperative cardiac, joint, and spine order sets. Additionally, the APRNs at the PREP center have daily access to their own meaningful use data, which includes their e-prescribing rates, via a dashboard that is refreshed weekly (W. Greene, personal communication, February 12, 2017). This is a powerful function given that ongoing evaluation of progress with real time data can strengthen adoption and sustainability (Cresswell et al., 2013). In conclusion, the US government is utilizing HIT, such as e-prescribing, as one strategy to reform the healthcare system and in conjunction with the evidence displaying improved patient safety and feasibility, it is reasonable to replicate similar QI projects in other healthcare settings.

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Table 1.
Electronic prescribing rates per week and totals during the last month of project implementation among advanced practice registered nurses (N= 7) in the procedure readiness evaluation and preparation (PREP) center

Week	Eligible Number of Patients	E-Rx Received	No E-Rx Received
7	12	6	6
8	13	6	7
9	14	9	5
10	8	7	1
11	6	5	1
Total	53	33	20
Mean		66.2%	33.7%
SD		18.9	18.8

Note. E-Rx= Electronic prescription; SD= Standard deviation.

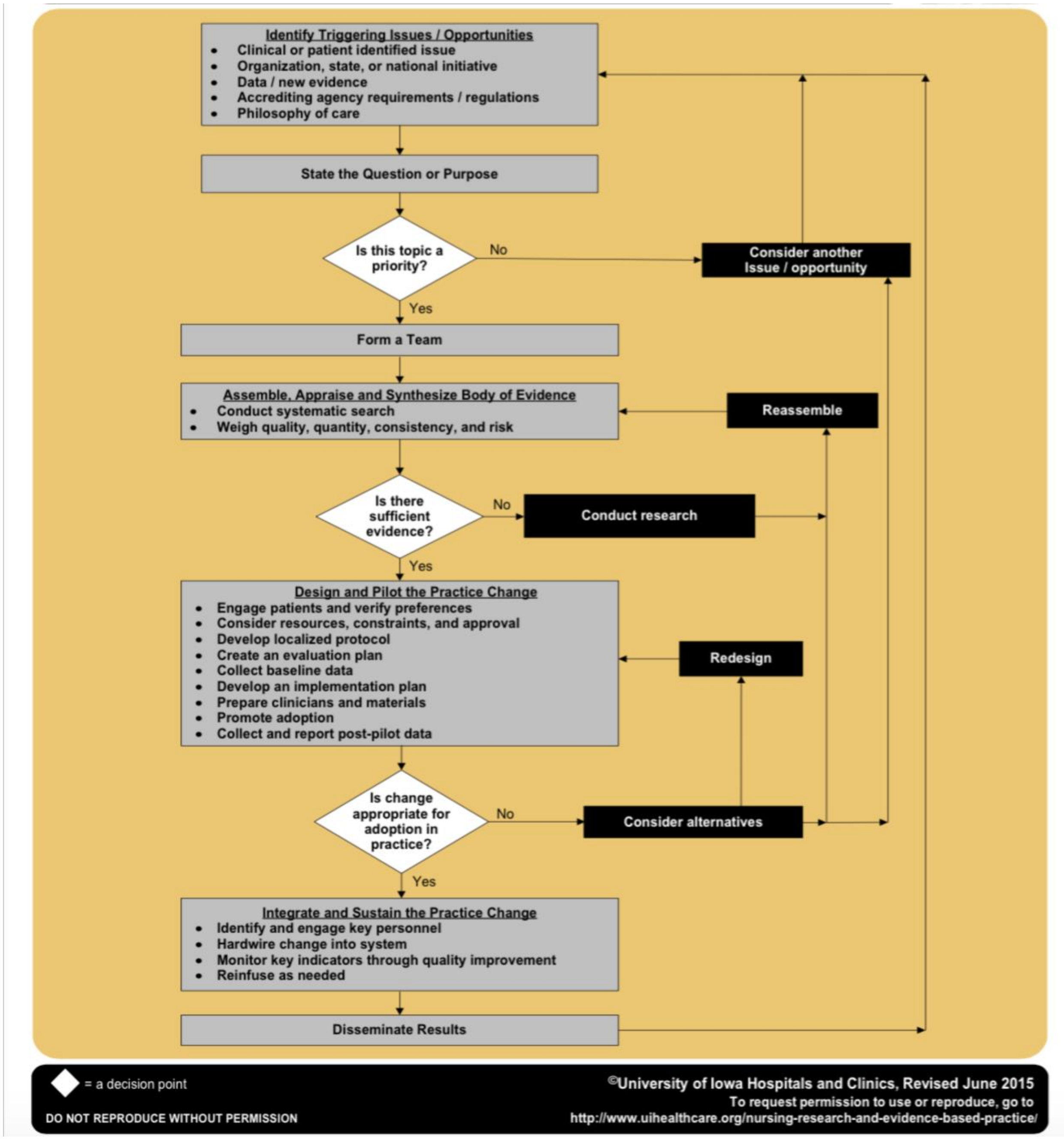

Figure 1. The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care. Used/Reprinted with permission from the University of Iowa Hospitals and Clinics. Copyright 2015. For permission to use or reproduce the model, please contact the University of Iowa Hospitals and Clinics at (319)384-9098.

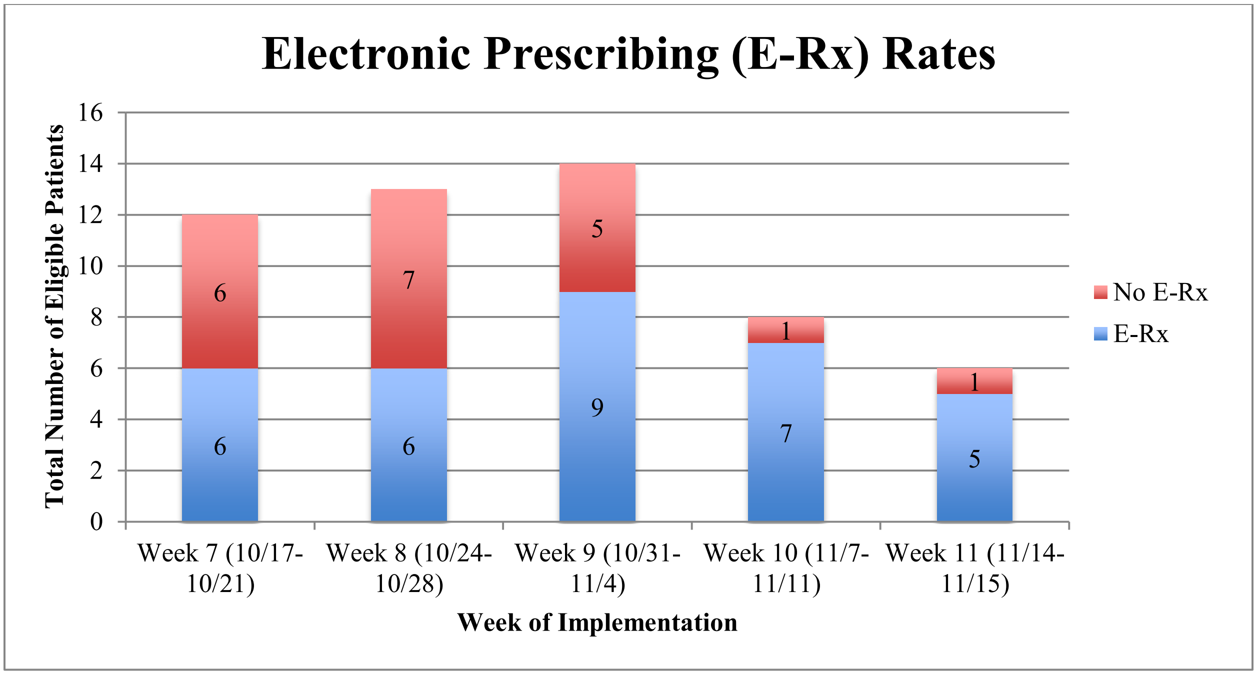

Figure 2. Weekly comparisons of the total number of eligible patients (*N*= 53) in the procedure readiness evaluation and preparation (PREP) center who did (*n*=33) and did not (*n*=20) receive an electronic prescription by an advanced practice registered nurse (*N*= 7) during the final month of project implementation

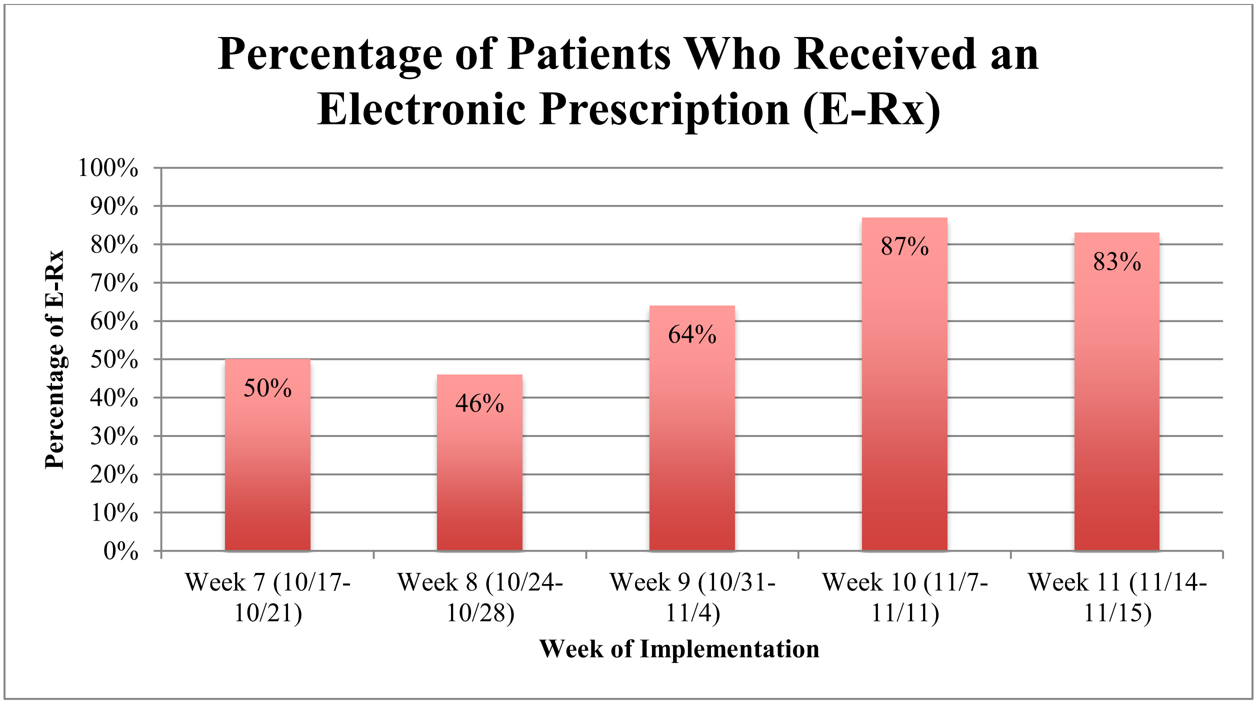

Figure 3. Weekly averages, during the final month of project implementation, displaying the percentage of eligible patients (*N*= 53) that received an electronic prescription (*n*= 33) by an advanced practice registered nurse (*N*= 7) in the procedure readiness evaluation and preparation (PREP) center

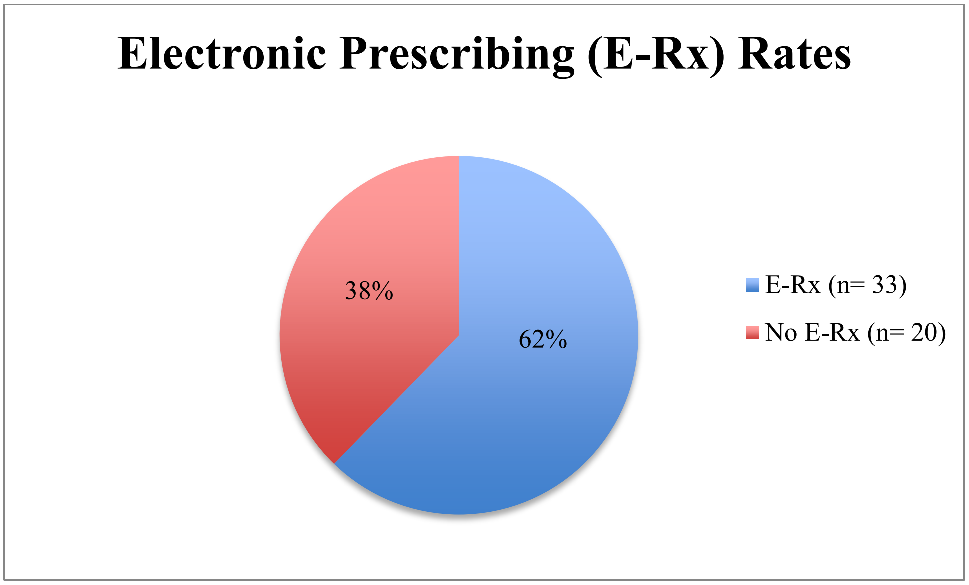

Figure 4. Comparison of the total number of eligible patients (*N*= 53) in the procedure readiness evaluation and preparation (PREP) center who did (*n*= 33) and did not (*n*= 20) receive an electronic prescription by an advanced practice registered nurse (*N*= 7) during the final month of project implementation

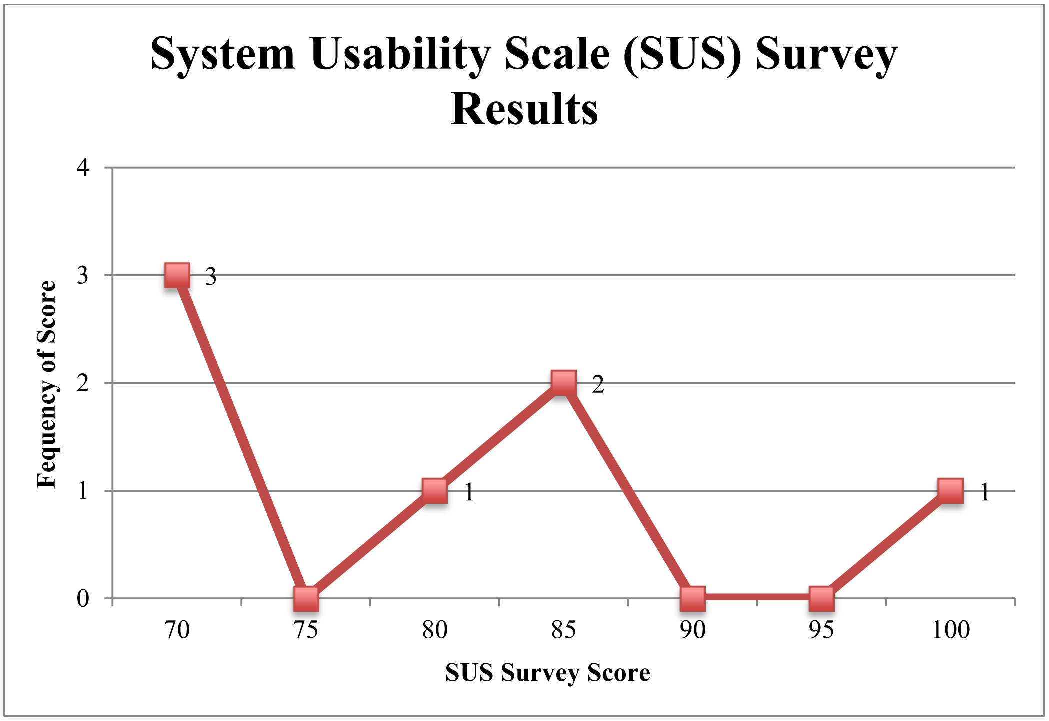

Figure 5. Distribution of advanced practice registered nurse (*N*= 7) scores on the System Usability Scale Survey, with scores rounded to the nearest whole number

Appendix A

Evidence Rating Table

Johns Hopkins Nursing Evidence-Based Practice Rating Scale (Dearholt & Dang, 2012)

						Evidence Rating	
#	Author(s) & Date	Study Objective or Purpose	Study Design & Sample Size	Results	Strengths & Weaknesses	Strength (Level)	Quality
1	Abramson et al., 2011	To assess the effects of an electronic prescribing system on the rates of ambulatory prescribing errors.	• Prospective, nonrandomized pre-post design with concurrent controls from 11 different adult community-based small ambulatory care practices. • 21 ambulatory care providers were studied at baseline and one year follow-up; 6 adopted electronic prescribing and 15 continued to use paper-	*Results:* • Error rates decreased 1.5 fold for those who adopted electronic prescribing and went from 26.0 per 100 prescriptions at baseline (95% confidence interval 17.4- 38.9) to 16.0 errors per 100 prescriptions at one-year follow up (95% confidence interval 12.7-20.2; *p*= 0.09). • Error rates among those who continued to paper-prescribe remained unchanged at one-year follow-up (*p*= .54). • Providers who adopted electronic prescribing had	• *Strengths:* ○ Described the features within the utilized electronic prescribing system. ○ Thoroughly discussed the data collection and review methods. ○ Good to excellent interrater reliability was established between the individuals reviewing prescriptions and charts- enhances internal validity. ○ Researchers utilized appropriate statistical analyses and adjusted for clustering- enhances internal validity.	2	B

			based prescribing. • Prescriptions were collected at baseline and one year follow-up for both groups. • 2,432 paper prescriptions at baseline and 2,079 prescriptions (1,543 paper prescriptions & 536 electronic prescriptions) at follow-up were reviewed.	significantly lower rates of prescribing errors at one year, compared to the providers who continued to utilize paper prescribing methods (16.0 compared to 38.4 per 100 prescriptions, $p<.001$). • Electronic prescribing reduced many types of errors. Illegibility errors were high at baseline and eliminated by electronic prescribing. Additionally, electronic prescribing eliminated almost all types of rule violations.	○ No significant differences between the two prescriber groups were present, in terms of demographics or the incidence/types of errors at baseline- enhances internal validity. • *Weaknesses:* ○ Study design- non-randomized and small sample size- 21 providers were included in the study, and only 6 adopted electronic prescribing- limits generalizability. ○ Study conducted in one geographic region, among community-based practices- limits generalizability. ○ The utilized electronic prescribing system was imbedded within an electronic health record that		

					had clinical decision support features- limits generalizability for standalone systems. o Providers were aware that their prescriptions were being reviewed for errors- threat to internal validity (Hawthorne effect). o During electronic prescribing implementation, providers had technology support- limits validity if others do not have such support. o Patients of providers who adopted electronic prescribing and received prescriptions were significantly older than patients of non-adopters at one year (p<0.001) and more likely to be male (p<0.01)- threat to		

					validity. o Although it may be related to the small sample size, the *p* value was not statistically significant when comparing error rates at baseline and one year follow-up for electronic prescribers (*p*=0.09)- risk for type I error. o Some of the calculated 95% confidence intervals were wide, which may be related to the small sample size- threat to internal validity. o No power analysis was reported- risk for committing a type II error.		
2	Ammenwerth et al., 2008	To determine the effect of electronic prescribing on the risk of medication errors and	• Systematic and quantitative review of 27 studies. • Only field studies were included, no lab	*Results:* • Medication errors: 25 studies reported on the risk of medication errors and 23 showed a significant relative risk reduction	• *Strengths:* o Utilized search strategies/databases were discussed. o The inclusion/exclusion	3	B

		adverse drug events.	or simulation studies were used. • Most of the included studies compared electronic prescribing to handwritten ordering. • Most were before-after/ time-series analyses and only 2 were randomized control trials. • Of the 27 studies, 15 evaluated medication errors, 2 evaluated adverse drug events, and 10 reported on both.	(Risk ratio between 0.01 and 0.87), which indicates a relative risk reduction for medication errors between 13% and 99%. • Potential adverse drug events: 9 studies reported on the risk of potential adverse drug events and 6 showed a significant relative risk reduction (Risk ratio between 0.02 and 0.65), which indicates a relative risk reduction for potential adverse drug events between 35% and 98%. • Adverse drug events: 7 studies reported on the risk of adverse drug events; however, 1 was excluded because no events in either group had occurred. 4 of the 6 remaining showed a significant relative risk reduction for adverse drug events. The risk ratio was between 0.16	criteria were explained. Studies written in all languages were included, all patient groups and clinical settings, and electronic prescribing systems regardless of level of decision support were included in the review- strengthens external validity. ○ Researchers included their utilized definitions for the studied outcomes and used each papers definition of the terms medication error and adverse drug event- strengthens internal validity. ○ Data extraction and study quality assessments were all discussed. ○ Authors included studies that evaluated both		

				and 0.70, which indicates a relative risk reduction for adverse drug events between 30% and 85%. • During sub-group analyses, studies comparing handwritten prescriptions with electronic prescriptions showed a higher relative risk reduction in errors than other comparison groups. Furthermore, electronic prescribing systems with advanced decision support seemed to show higher relative risk reduction when compared with those systems that had limited to no decision support. • Authors concluded that electronic prescribing seemed to be a useful intervention for reducing the risk of medication errors and adverse drug events.	commercially available and homegrown electronic prescribing systems, including those with or without decision support features- strengthens external validity. ○ The risk ratios between groups seemed to be similar for all levels of care, patient groups, type of drug, and study design. • *Weaknesses:* ○ The majority of the studies were conducted in the United States in inpatient care settings- limits generalizability. ○ Authors note that the reporting quality and study methodology/design were inadequate for some of the included studies; similarly, only 2 were		

					randomized control trials and few had comparison groups threat to internal validity. ○ Most studies were single center studies. Outcomes seemed to be measured validly and reliably in only a few of the studies and only half of the studies adjusted for confounding or clustering- threat to internal validity. ○ Only published studies were included; additionally, some studies may have been overlooked due to variations in electronic prescribing terminology. The definitions for the measured variable(s) often differed between studies. ○ In most of the included studies,		

					electronic prescribing systems had only been implemented for a short time; therefore, long-term effects were not studied.		
3	Fernando et al., 2011	To assess if electronically delivered prescriptions lead to reduced pharmacy wait times, improved patient satisfaction, and improved compliance with prescriptions.	• Prospective, randomized study conducted at the Ronald Regan UCLA Medical Center emergency department (ED), which is an academically affiliated institution. • All patients, assuming they did not meet any of the exclusion criteria, discharged from the ED without a narcotic prescription were eligible for the study. • Study investigators,	*Results:* • Primary compliance rates did not differ between the two study groups (*p*= 0.578). • Medications were ready for immediate pick-up for 53.5% (54/101) of patients who had their prescriptions electronically sent to the pharmacy, compared to 7.5% (7/93) of patients who were given a paper prescription (*p*<.001). • Pharmacy wait times were significantly longer for those patients that were given a paper prescription (*p*<.001). • Patients who had their prescription sent electronically, reported greater satisfaction in regards to the process of	• *Strengths:* ○ The inclusion/exclusion criteria were reviewed. ○ The study protocol was explained. ○ Participants were enrolled 7 days a week- strengthens validity. ○ The randomized design and sufficient sample size help to strengthen internal validity. ○ Patient demographics were similar between the control group and the intervention group. ○ All interviews were conducted only with the patient-	1	B

			research associates, and study participants were blinded to study arm enrollment until after consent was obtained. • Study participants were then randomized into either the control group or the intervention group. • Patients in the control group received standard care (paper prescription filled at a pharmacy of their choice) and those in the intervention group received a prescription that was electronically sent directly a	obtaining medications. 66.3% of patients in the intervention group rated their satisfaction with the process as very good/excellent, compared to 48.4% of patients in the control group (p=.034). • Overall, electronic prescribing reduced pharmacy wait times and improved patient satisfaction.	strengths internal validity. ○ All patients were asked the same series of questions- strengths internal validity. ○ Utilized survey questions were included. ○ Completed statistical analyses and utilized software were reviewed. ○ Investigators conducted a power analysis to determine sample size- decreases the risk of committing a type II error. • *Weaknesses:* ○ Convenience sample from a single academic medical facility- limiting generalizability. ○ The majority of patients in this study's geographic location were of higher socioeconomic status- limits		

			pharmacy of their choice. • Patients were contacted by telephone 7 days after ED discharge and continued contact was attempted for up to 31 days. • 1,114 patients were assessed for eligibility and 454 patients were enrolled however, follow-up and data analysis was conducted on 224 patients.		generalizability. ○ Only ED patients were included- may limit generalizability ○ The following patients were excluded: those receiving schedule 1 or 2 narcotic prescriptions, those who were admitted to the hospital, those with psychiatric complaints, those that did not provide contact information/ could not perform a follow-up telephone interview, those who could not understand English, and non-California residents- all threaten external validity. ○ Participants were only enrolled between 8AM and 12AM- limits generalizability to other hours of the day. ○ Researchers		

					had a low rate (52.4%) of successful follow-up- threatens study results. ○ Not all patients were contacted at the same time, which can introduce recall bias (time frame ranged from 7 to 31 days)- threatens internal validity. ○ Researchers did not compare primary medication compliance rates with actual insurance data, which may be a problem considering some patients falsely report getting their prescriptions filled- threatens internal validity. ○ Research assistants who conducted follow-up phone calls were not blind to study groups, potentially leading to observer bias. ○ No mention		

					about the reliability or validity of the instrument used to interview patients- threat to internal validity. ○ Several of the patients in the intervention group experienced technical problems with the electronic transmission of their prescription- threat to internal validity.		
4	Michelis et al., 2011	To investigate whether electronic prescribing with formulary decision support (FDS) was correlated with improved attainment of patients' low-density lipoprotein (LDL) goals. FDS helps to inform providers about drug costs specific to each	• Retrospective cohort study conducted at a single, multi-specialty outpatient academic medical practice in Washington, DC. • 2,218 patients' electronic health records were queried. • Patients had initial and follow-up lipid panels performed. • While the	*Results:* • At initial presentation, 1,422 patients were at their identified LDL goal and 796 patients were not at their identified LDL goal. • 612 (77%) received an electronic prescription with FDS and the remaining 184 received a paper prescription. • Of the 796 patients not initially at goal, 393 (49%) were at goal at follow-up: 51%	• *Strengths:* ○ Investigators described inclusion/exclusion criteria. ○ Researchers had a fairly large sample size- enhances external validity. ○ Researchers described study protocol and explained how patients' LDL goals were determined. ○ Data collection techniques were thoroughly	2	B

		patient.	electronic prescribing system did not include a clinical decision support tool for guideline adherence, it did include FDS.	in the electronic prescription group and 44% in the paper prescription group. • Patients who received an electronic prescription were 59% more likely to attain their identified LDL goal (Odds ratio= 1.59; 95% confidence interval 1.12-2.25). • For each $10 increase in prescription price at the initial visit, the likelihood of being at goal decreased by 5% (Odds ratio= 0.95%; 95% confidence interval 0.93- 0.98). This is likely related to the fact that patients with an electronic prescription were 70% (*p*= .0004) more likely to receive a generic statin.	discussed. ○ Researchers note that provider characteristics were not significant predictors of whether patients were at LDL goal at follow up; furthermore, there were no major differences in provider characteristics between those who electronically prescribed and those who paper prescribed- strengthens interval validity. ○ Authors discussed utilized statistical software and conducted appropriate analyses to control for several potential confounding variables- strengths internal validity. ○ The average time between initial and follow-up lipid panels were similar		

					between those who received an electronic prescription and those who received a paper prescription- enhances internal validity. • *Weaknesses:* ○ The retrospective, non-randomized design- threat to internal validity. ○ The study was conducted at a single outpatient academic medical center- limits generalizability. ○ Convenience sample- threat to external validity. ○ For inclusion into the study, encounter had to be with a primary care physician, cardiologist, or endocrinologist- limits generalizability. ○ Electronic prescribing systems without FDS may		

					produce different results- limits generalizability.		
5	Westbrook et al., 2012	To evaluate the effectiveness of two commercially available electronic prescribing systems in reducing prescribing error rates.	• A before/ after study involving medication chart audits. • 2 different commercially available electronic prescribing systems were implemented at 2 major teaching hospitals in Sydney, Australia. • At hospital A, data was collected from 4 wards pre and post electronic prescribing implementation- 1 ward was assigned the intervention and the other 3 wards served as controls. • At hospital B, the intervention	*Results:* • The use of an electronic prescribing system was associated with a statistically significant reduction in error rates in all 3 intervention units (Unit 1: 66.1% reduction [95% confidence interval 53.9%-78.3%]; Unit 2: 57.5% reduction [95% confidence interval 33.8%-81.2%]; Unit 3: 60.5% reduction [95% confidence interval 48.5%-72.4%]). • The use of an electronic prescribing system resulted in a decreased amount of errors at hospital A from 6.25 per admission (95% confidence interval 5.23-7.28) to 2.12 (95% confidence interval 1.71-2.54; $p<0.0001$) and at	• *Strengths:* ○ A variety of units were included in the study, enhances generalizability. ○ Given the study design, concurrent controls were available at hospital A- enhances internal validity. ○ Two different hospitals were included in the study- enhances generalizability. ○ The type and severity of errors were similar between both hospitals at baseline- strengthens internal validity. ○ Error rates and error types between individual units within the hospitals were comparable at baseline- strengthens	2	B

			was implemented on 2 wards and error rates were evaluated during the pre and post electronic prescribing implementation periods. • During the pre-intervention period, all units utilized paper medication prescriptions/charts. • Researchers conducted 3,291 chart adults (1,923 at baseline and 1,368 post electronic prescribing implementation).	hospital B from 3.62 (95% confidence interval 3.30-3.93) to 1.46 (95% confidence interval 1.20-1.73; $p<0.0001$). • A decrease in errors was attributed to reductions in unclear, illegal, and incomplete orders. • There was only a small change in clinical error rates, but serious errors decreased by 44% (0.25 per admission to 0.14 post-implementation; $p=0.0002$) across all units that implemented electronic prescribing. Control groups saw no significant changes during the post-implementation periods. • Per 100 patient days, all intervention groups saw a significant decline in total prescribing error rates (Unit 1: 66.5%	internal validity. ○ Authors described data review/collection protocols. 3 different pharmacists, who were all independent of the hospitals, reviewed the medication charts- could have limited bias. ○ For post intervention data collection, researchers allowed time for clinicians to gain experience/ comfort before gathering data- enhances internal validity. ○ Researchers utilized specific definitions for error identification. ○ Interrater reliability between reviewers was established- enhances internal validity. ○ Steps were taken to ensure		

				decline; Unit 2: 74.1% decline; Unit 3: 64.1% decline).	consistency between pre and post data collection techniques- enhances internal validity. o Two different commercial electronic prescribing systems were implemented- enhances generalizability. o During the post-intervention period, providers were required to electronically prescribe, enhancing internal validity. o Authors discuss utilized statistical software and analyses. • *Weaknesses:* o The study was conducted at a large teaching hospital, limiting generalizability. o The study took place in Australia, where prescribing styles		

					differ than in the United States. ○ During the intervention period, both hospitals still continued to paper prescribe certain medications- threatens validity. ○ Hospital A had higher rates of procedural and clinical errors at baseline then hospital B- threatens internal validity. ○ Hospital B had no control groups to compare findings. ○ No power analysis was reported- could be at risk for committing a type II error.		
6	Devine et al., 2010	To evaluate the effect of a basic, ambulatory computerized provider order entry (CPOE) system on medication	• Quasi-experimental, pretest-post-test design in a community-based multi-specialty health system not affiliated with an	*Results:* • Frequency of errors decreased from 18.2% to 8.2% (Reduction in adjusted odds of 70% [Odds ratio: 0.30; 95% confidence interval 0.23 to 0.40; *p*<0.001]).	• *Strengths:* ○ The utilized CPOE and electronic heath record systems were described. ○ The studied medical practice was rather large (60	2	B

		errors and associated adverse drug events.	academic medical center in Washington. • The intervention consisted of implementing a basic CPOE system with limited clinical decision support capabilities. • Compared 5,016 (Pre-implementation) handwritten prescriptions to 5,153 (Post-implementation) electronically prescribed prescriptions to identify errors.	• Largest reductions were seen in adjusted odds for errors relating to illegibility (97%), use of inappropriate abbreviations (94%), and missing information (85%). • There was a 57% reduction in adjusted odds for errors that did not cause harm (potential adverse drug events) (Odds ratio: 0.43; 95% confidence interval 0.38 to 0.49). • The decrease (49% reduction) in the number of errors that did cause harm (preventable adverse drug events) was not statistically significant, which may have been related to the few number of errors in this category.	clinics in 14 locations) and data was included from all clinic sites and all provider specialties- enhances external validity. ○ 242 providers were included in the final analysis. ○ Standardized, reputable definitions/tools for error classifications were used- strengthens internal validity. ○ Both new and renewal prescriptions were in included in the analyses- strengthens internal validity. ○ Data collection strategies were discussed- high interrater reliability between researchers was established- enhances internal validity. ○ Appropriate statistical analyses		

					were conducted to adjust and account for extraneous or confounding variables related to the patient, provider, medication, and other worldly factors- enhances internal validity. ○ Researchers allowed a 6-month time lag after electronic prescribing implementation to review post-implementation data-enhances conclusion validity. ○ During the study time frame, no other medication safety measures were occurring- enhances internal validity. ○ Results were similar to existing literature. • Weaknesses: ○ Conducted in a community based, independently owned practice not affiliated		

					with an academic medical center- limits generalizability. o Convenience sample- limits generalizability. o Study's design- no randomization and no control group- threatens internal validity. o Prescription reviewers were not blinded- potentially introduces bias. o The CPOE system implemented had limited clinical decision support capabilities- limiting generalizability. o During data collection, the dataset was limited to prescriptions filled at the practice's onsite retail pharmacies- although a weighting variable was used to address this limitation, it can still weaken validity.		

					Prescriptions were excluded if they were transferred to or from outside pharmacies- weakens conclusion validity. ○ Although statistical analytics were used to address these limitations, there were significant differences among patient, prescriber, and prescription characteristics when comparing pre and post implementation data- limits internal validity.		
7	Radley et al., 2013	To determine a nationally representative estimate of medication error reductions (over1 year) in hospitals that are attributable to electronic prescribing through a computerized provider order	• Systematic review with applied random-effects meta-analytic techniques. • Included 4,701 surveyed hospitals and 9 studies.	*Results:* • Processing a prescription drug through a CPOE system decreased the likelihood of error for that particular order by 48% (95% confidence interval 41% to 55%). • Based off of the effect size and the amount of CPOE use in hospitals in 2008, researchers estimated a	• *Strengths:* ○ Large number of hospitals included- enhances external validity. ○ Included several data sources to determine estimates- enhances internal validity. ○ Data from both adult and pediatric facilities were included-	3	B

		entry (CPOE) system.		12.5% decrease in medication errors, which is equal to the reduction of approximately 17.4 million medication errors in the United States over a 1-year period. • If all United States hospitals adopted CPOE, up to 51 million medication errors per year could be avoided.	enhances generalizability. ○ Utilized statistical analyses were explained. Authors attempted to use adjustments to account for differences. ○ The inclusion/exclusion criteria were discussed. ○ For included studies, the mode of error detection had to be consistent both before and after the implementation of electronic prescribing- enhances internal validity. Studies using only voluntary error detection methods were excluded. ○ Authors only utilized peer-reviewed studies. • *Weaknesses:* ○ Long-term care facilities and federally owned		

					hospitals were excluded- limits generalizability. o Only acute care facilities within the United States were included- limits generalizability. o The majority to hospitals studied were large, urban, academic facilities- limits generalizability. o No mention about the validity or reliability for the utilized survey- threat to internal validity. o There was a significant amount of heterogeneity among utilized studies, such as differing levels of rigor, methodology, and definitions for medication error classification. o Limitations during result interpretation exist, as limitations extended from the utilized		

					primary sources.		
8	Schleiden et al., 2015	To describe older adult patients' perceptions and experiences with electronic prescribing and to further explore the impact electronic prescribing has on patient-provider communication.	• Non-experimental study in which 75 patients completed a telephone survey assessing their perceptions of electronic prescribing.	*Results:* • 53.3% of participants had heard of electronic prescribing and 84% expected to receive electronic prescriptions. • About 80% of participants preferred electronic prescriptions, as compared to paper prescriptions. Reasons include: convenience by saving time and trips to the pharmacy and not worrying about losing the paper prescription. • Of the 57 participants whose doctors sent their prescriptions electronically, 93% reported being very satisfied with their doctor and 84% reported being very satisfied with their pharmacist. • Participants	• *Strengths:* ○ Utilized statistical analyses were included. ○ Data collection and survey measures were discussed. ○ The inclusion criterion was discussed. • *Weaknesses:* ○ Non-experimental design and convenience sample- limits generalizability. ○ Only patients over the age of 50 and living within 1 hour of Pittsburg, Pennsylvania were included- threat to external validity. ○ Small sample size- threat to external validity. ○ The majority of participants were female and Caucasian- threat to external validity. ○ The majority	3	C

				who received an electronic prescription reported having discussions with their doctor about the importance of taking medications, potential side effects, and the cost of medications more frequently than did the patients who received a paper prescription. • 68.4% of those who had used electronic prescribing believed that such technology improved the care they received by at least a little. • Only 10.5% of participants reported that having a paper prescription helped them remember to get their medication filled.	of patients included in the study received electronic prescriptions, while only a few received paper prescriptions. ○ Only patients with telephone access were included- threat to external validity. ○ No mention about the surveys validity or reliability was included- potential threat to internal validity.		
9	Matthews et al., 2013	To determine the role of electronic prescribing in complying with the sepsis guidelines for antibiotic	• Quasi-experimental pre-post intervention study design. • The intervention included	*Results:* • In the pre-intervention group, only 40% of patients received their antibiotic within the 1-hour recommended time	• *Strengths:* ○ Utilized statistical analyses were discussed. ○ Methodology and study protocol were discussed.	2	B

		administration, following simple modifications to the electronic prescribing system within an intensive care unit (ICU).	modifying the electronic prescribing system that providers used in an acute care setting (default dosing times for antibiotics were eliminated and red flag ions were used so clinicians would not overlook a newly ordered drug; ICU staff education was reinforced) • ICU admissions within 2 separate 3-month periods, pre and post intervention, were retrospectively reviewed. • 100 patient encounters were reviewed.	frame; however, in the post-intervention group, 67% of patients received their antibiotic within the 1-hour recommended time frame (*p*= .0018). • Overall, researchers found a statistically significant decrease in antibiotic delays following simple modifications to the electronic prescribing system and enhanced staff training. • These results display the importance of allowing institutions to modify their systems in order to create the best possible patient outcomes.	o Current institutional practices were reviewed. • *Weaknesses:* o Retrospective study design with no concurrent controls-threat to internal validity. o Study conducted at one, large hospital in the United Kingdom-limits generalizability. o Study assessed only ICU patients-threat to external validity. o Heterogeneity was present between patient cases. o Authors did not report conducting a power analysis- risk for committing a type II error. o Both modifications to the electronic prescribing system and enhanced staff education were implemented at the same time; therefore,		

					it could be difficult to determine which intervention actually produced results- threat to internal validity.		
10	Jariwala et al., 2013	To provide an update on electronic prescribing use among primary care providers, describe their experience with electronic prescribing, and discuss their decisions to implement electronic prescribing in their practices.	• Non-experimental, cross-sectional design. • An internet-based survey was administered to 443 primary care providers.	*Results:* • About 58% of respondents were electronically prescribing at the time of survey completion and more than 20% stated they planned to implement electronic prescribing within the next 6 months. • 83% of providers who were utilizing electronic prescribing reported that they were satisfied with the electronic prescribing system. • 82% of providers utilizing electronic prescribing systems indicated they preferred electronic prescribing to traditional, paper-based methods. • Overall, researchers found providers to be	• *Strengths:* ○ Theoretical framework was used to support study design and results. ○ Questions within the utilized survey were included. ○ Utilized statistical tests were discussed. ○ No statistically significant demographic differences between electronic prescribers and paper prescribers existed ($p > 0.05$)- enhances internal validity. • *Weaknesses:* ○ Convenience sample- limits generalizability. ○ Although researchers made	3	B

				satisfied with their electronic prescribing systems, but that software and information technology problems are present. • Collaborative efforts between clinicians and software experts are needed to resolve inefficiencies/ system defects.	clear that the study was open to both electronic prescribers and paper prescribers, self-selection bias may have been present- threat to internal validity. ○ Only primary care/internal medicine providers from the United States were included- threat to external validity. ○ Survey was only available for completion for a short time. ○ No mention about the surveys validity or reliability was included- potential threat to internal validity.		
11	Nuckols et al., 2014	To quantitatively assess the effectiveness of computerized provider order entry (CPOE) at reducing preventable	• Systematic review and meta-analysis of 16 studies. • Studies were eligible if they compared CPOE with paper-order	*Results:* • Compared with paper-order entry, CPOE was associated with half as many preventable ADEs (pooled risk ratio (RR)= 0.47, 95%	• *Strengths:* ○ Authors adhered to the recommendations from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses	3	B

		adverse drug events (ADEs) in hospital related acute care settings.	entry and examined either rates of preventable ADEs or medication errors. • 16 studies addressed medication errors and six also addressed preventable ADEs.	confidence interval 0.31- 0.71) and medication errors (RR= 0.46, 95% confidence interval 0.35-0.60). • Overall, while results varied between studies, implementing CPOE is associated with a greater than 50% reduction in preventable ADEs and medication errors in the hospital setting.	(PRIMSA) statement. ○ Inclusion and exclusion criteria were explained. ○ The included studies were conducted in a variety of clinical settings, enhancing generalizability. ○ Inclusion of articles in this review was made only after rigorous review by multiple researchers. ○ A minimum criteria for study quality was instituted by the authors. Studies were excluded if researchers did not describe methods for detecting medication events or that used incident reporting alone, which have been found to detect very few errors. ○ Authors provided their definition for preventable ADEs		

					(injuries to patients due to medication errors) and medication errors (errors in the process of prescribing, transcribing, dispensing, or administration of medication, which had the potential to cause harm) and excluded studies that only assessed low risk medication errors. ○ Researchers explained all statistical tests that were performed. ○ The reductions in preventable ADEs and medication errors were similar across studies with different intervention designs and different implementation, contextual, and methodological characteristics. • *Weaknesses:* ○ For the		

					included studies, the definitions of medication errors and methods used to detect them varied across studies. o Many of the included studies used weak designs, threatening internal validity. o Most studies were conducted in academic centers, limiting generalizability to community facilities. o Studies evaluating pediatric patients were excluded, limiting generalizability.		

Appendix B

Detailed Project Implementation Plan and Timeline

What	When	How
Pre-Implementation • **Identified key institutional stakeholders** ○ All full-time, part-time, and per diem advanced practice registered nurses (APRNs) working in the Procedure Readiness Evaluation and Preparation (PREP) center ○ Medical director for the PREP center ○ Organizational leadership (e.g. director of quality and safety; director of infection prevention and hospital epidemiology) ○ Meaningful use representative ○ Clinical informatics representative	• Spring/Summer 2016	• Meet with identified individuals to review resources/facilitators and constraints/barriers • Discussed project feasibility, significance, goals, and sustainability. • Attended PREP center staff meetings and scheduled visits to form rapport with PREP center staff and identify any concerns • Following approval from the PREP center medical director and input from the PREP center APRNs, collaborated with the clinical informatics team to modify the preoperative cardiac, joint, and spine surgical order sets. Modification of the order sets would include the appropriate mupirocin regimen, whereby the APRNs could electronically prescribe (e-prescribe) from directly within the order set. • Identified a project champion(s) from the PREP center • Reviewed data collection strategies

• **Timeline considerations** ○ Submit finalized copy of scholarly project proposal to all committee members ○ Present final proposal to all committee members ○ Submit scholarly project query to the University of Maryland Institutional Review Board ○ Scholarly project implementation ○ Scholarly project analysis, synthesis, and evaluation ○ Submit final scholarly project manuscript to all committee members for review ○ Present final scholarly project to all committee members	• April 25, 2016 • May 2016 • Summer 2016 • September 2016- December 2016 • Spring 2017 • March 21, 2017 • April 11, 2017	
• **Educated PREP center APRNs on e-prescribing**	• August 15, 2016- August 31, 2016	• Education provided via PowerPoint presentation and face-to-face interaction during informal visits and during staff meetings. Discussed definition, benefits, and significance of e-prescribing. Reviewed meaningful use requirements and goals for this quality improvement (QI) project. Provided staff with a comprehensive review on how to successfully transmit a prescription electronically. Providers were instructed to verify and select the

		patient's pharmacy of choice prior to electronic transmission. Providers were instructed to e-prescribe the patient's prescription at the start of the visit.
Implementation • **Implemented e-prescribing within the PREP center**	• September 1, 2016- November, 15, 2016	• Reminder signs advocating for e-prescribing were placed throughout the PREP center and in each of the patient examination rooms to remind and encourage staff to e-prescribe. • Laminated reference sheets were provided to the APRNs, serving as a step-by-step guide on how to e-prescribe from within the electronic health record (EHR) and the intended order sets. • Weekly needs assessments were conducted, via either e-mail or face-to-face interaction, in addition to monitoring aggregate e-prescribing compliance data. Staff was re-educated as needed. Perceived and encountered barriers were continually assessed. • Weekly updates were communicated to all APRNs via either e-mail or face-to-face interaction.
Post-Implementation • **APRNs completed the System Usability Scale (SUS) Survey**	• December 2016	• All APRNs were invited to complete the SUS survey at the end

		of this QI project. Completion was voluntary and anonymous. • Paper copies of the survey were distributed by the project champion, collected, and then given to the PC for analysis.
• **Disseminated results at the PREP center**	• Spring 2017	• Provided the APRNs with final e-prescribing compliance data, as well as the results from the SUS survey. • Discussed the significance (e.g. The Center for Medicare and Medicaid Services Stage 2 Meaningful Use Objectives) and continued sustainability (e.g. Self monitoring via the Meaningful Use Dashboard within the electronic health record) of e-prescribing.

Appendix C

Detailed Data Collection and Analysis Plan

What	When	How
<u>Pre-Implementation</u>		
• ***Data Collection:*** Recorded the advanced practice registered nurses (APRNs) who received education prior to electronic prescribing (e-prescribing) implementation.	• August 15, 2016- August 31, 2016	• On a spreadsheet, documented the APRNs who received education.
• ***Data Analysis***	• Spring 2017	• Utilized descriptive statistics, documenting frequencies and percentages (Microsoft Excel Software).
<u>Post- Implementation</u>		
• ***Data Collection:*** Determined the rate of e-prescribing compliance among APRNs in the Procedure Readiness Evaluation and Preparation (PREP) Center	• October 15, 2016- November 15, 2016	• Performed a retrospective chart review to determine the number of preoperative mupirocin prescriptions that were transmitted electronically by the APRNs for cardiac, joint, and spine surgical patients.
• ***Data Analysis***	• Spring 2017	• Assessed weekly e-prescribing compliance rates during the final month of implementation, utilizing descriptive statistics to note the frequencies and percentages. Weekly averages during the final month were then calculated to determine the aggregate mean and standard deviation (Microsoft Excel

		Software).
• ***Data Collection:*** Assessed the APRNs' perceptions of the usability of the e-prescribing system within the electronic health record (EHR) system.	• December 2016	• The APRNs were all invited to complete the System Usability Scale (SUS) survey.
• ***Data Analysis***	• Spring 2017	• SUS survey results were calculated according to standard SUS methodology, and descriptive statistics were calculated to determine the mean and standard deviation (Microsoft Excel Software).

Appendix D

University of Maryland Baltimore (UMB) Institutional Review Board (IRB) Approval

Research is Not Human Subjects Research   Inbox x

CICERO@som.umaryland.edu via somumaryland.onmicrosoft.com   6/10/16

to me

Not Human Subjects Research (NHSR) Confirmed

To: Cameron Lewis

Link: HP-00070325

An IRB Analyst has reviewed the information provided and has determined that the project meets the definition of *Not Human Subjects Research* (NHSR). IRB oversight is not required and no further actions are required.

Description:

Submission Title: Electronic Prescribing Implementation

POC: Joan Davenport

Please contact the HRPO at 410-706-5037 or HRPO@umaryland.edu if you have any questions.

Warning: This is a private message intended specifically for the above named receiver. If you are not the named receiver, or believe that you may have received this email in error, please forward it to cicero-help@som.umaryland.edu.

University of Maryland, Baltimore

Template:HP_NHSR Confirmed

Appendix E

System Usability Scale (SUS) Survey

Please check the box that reflects your immediate response to each statement. Don't think too long about each statement. Make sure you respond to every statement. If you don't know how to respond, simply check box "3."

	Strongly Disagree				Strongly Agree
1. I think that I would like to use this product frequently.	1	2	3	4	5
2. I found the product unnecessarily complex.	1	2	3	4	5
3. I thought the product was easy to use.	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this product.	1	2	3	4	5
5. I found the various functions in the product were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in this product.	1	2	3	4	5
7. I imagine that most people would learn to use this product very quickly.	1	2	3	4	5
8. I found the product very awkward to use.	1	2	3	4	5
9. I felt very confident using the product.	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this product.	1	2	3	4	5

Note. Adapted from "Determining What Individual SUS Scores Mean: Adding an Adjective Ratings Scale," by A. Bangor, P. Kortum, and J. Miller, 2009, *Journal of Usability Studies, 4*(3), p. 116.