A FEASIBILITY EVALUATION OF A DIGITAL PEN AND PAPER SYSTEM
FOR ACCOMPLISHING ELECTRONIC ANESTHESIA RECORD-KEEPING

by

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DEDICATION

I dedicate this doctoral journey to my dad, David Thornton, who looked forward to the day when I would be called “Doctor” and “wear the funny hat.” Unfortunately, he succumbed to his longstanding heart disease before I could claim the title and don the attire, but I know he is with me each day.
TABLE OF CONTENTS

LIST OF ILLUSTRATIONS.................................................................................................................. 9
LIST OF TABLES................................................................................................................................. 10
ABSTRACT............................................................................................................................................ 11

CHAPTER 1: INTRODUCTION ............................................................................................................. 13
Background and Significance ........................................................................................................... 14
Purpose............................................................................................................................................... 21
Summary........................................................................................................................................... 22

CHAPTER 2: INTRODUCTION ............................................................................................................. 23
Review of the Literature.................................................................................................................... 23
  Human Factors Engineering............................................................................................................. 23
  Human Computer Interaction ........................................................................................................ 25
  Sociotechnical HT Models............................................................................................................. 26
    The Information Success Model ................................................................................................ 26
    The Technology Acceptance Model ........................................................................................ 27
    Information Technology Adoption Model ................................................................................ 28
    The Task Technology Fit (TTF) Model .................................................................................... 29
    The Fit Between Individual Task Technology (FITT) Model .................................................... 29
  Diffusion of Innovation (DOI) Theory ......................................................................................... 31
The Conceptual Framework for This Feasibility Study ................................................................. 33
  Tasks.................................................................................................................................................. 35
  Environment ................................................................................................................................... 35
  Users ................................................................................................................................................ 37
  Technology ....................................................................................................................................... 37
Evidence Related to the Use of Digital Pen and Paper Technology ............................................. 39
  Stakeholders .................................................................................................................................. 41
Summary........................................................................................................................................... 41

CHAPTER 3: INTRODUCTION ............................................................................................................. 43
Methods............................................................................................................................................ 44
  Cognitive Walkthrough ............................................................................................................... 44
  Sample and Setting ....................................................................................................................... 44
Design and Procedures .................................................................................................................. 44
Instrumentation .............................................................................................................................. 46
Data Analysis ................................................................................................................................... 47
Stakeholder Analysis ...................................................................................................................... 47
  Setting and Sample ....................................................................................................................... 47
Design and Procedures .................................................................................................................. 48
Data Analysis Plan .......................................................................................................................... 48
TABLE OF CONTENTS – Continued

Data Management Plan .................................................................................................................. 48
Human Subjects’ Protection Plan ................................................................................................. 48
Summary ..................................................................................................................................... 49

CHAPTER 4: RESULTS ................................................................................................................ 50
Introduction ................................................................................................................................. 50
Results of Cognitive Walkthrough ............................................................................................. 50
  Description of the Sample ......................................................................................................... 50
Thematic Analysis .......................................................................................................................... 53
  Perceived Ease of Use ............................................................................................................. 53
  Perceived Usefulness ............................................................................................................... 54
  Reliability ............................................................................................................................... 56
  User Control of Data Entry .................................................................................................... 57
Observational Data ...................................................................................................................... 57
  User Satisfaction Survey Results ........................................................................................... 58
Results of the Stakeholder Interviews ......................................................................................... 60
Summary ..................................................................................................................................... 62

CHAPTER 5: DISCUSSION OF RESULTS ................................................................................. 63
Introduction ................................................................................................................................. 63
Summary of the Study .................................................................................................................. 63
Findings of the Precognitive Walkthrough CRNA Survey ........................................................ 67
Findings Specific to Cognitive Walkthrough ............................................................................... 70
Findings from the User Satisfaction Survey ............................................................................. 73
Findings from Stakeholder Interviews ....................................................................................... 73
Strengths of the Study ................................................................................................................ 74
Limitations of the Study ............................................................................................................. 74
Implications ................................................................................................................................. 75
Summary ..................................................................................................................................... 75

APPENDIX A: COMPUTER EXPERIENCE, SKILLS AND ATTITUDES SURVEY .......... 77
APPENDIX B: PROCEDURAL GUIDE FOR COGNITIVE WALKTHROUGH METHOD.... 81
APPENDIX C: MODIFIED QUIS/USER SATISFACTION SURVEY .............................. 84
APPENDIX D: PROCEDURAL GUIDE AND QUESTIONS FOR STAKEHOLDERS ....... 87
APPENDIX E: CRNA COMMENTS DURING COGNITIVE WALKTHROUGH .......... 89
APPENDIX F: CONSENT FORMS ......................................................................................... 95
APPENDIX G: IRB DOCUMENTS .........................................................................................102
TABLE OF CONTENTS – Continued

REFERENCES ................................................................................................................................. 105
LIST OF ILLUSTRATIONS

FIGURE 1. Conceptual framework for the feasibility study..................................................34

FIGURE 2. Diagram of anesthesia documentation tasks. .........................................................36

FIGURE 3. Constraints associated with anesthesia documentation tasks in various anesthetizing locations. .................................................................................37

FIGURE 4. Shareable Ink® product. .......................................................................................38
LIST OF TABLES

TABLE 1. Synopsis of technology adoption theories including key elements, strengths and potential weaknesses. ........................................................................................................................................32

TABLE 2. Years of experience for the CRNA participants in the cognitive walkthrough (n=7). 50

TABLE 3. Worked hours per week reported by the CRNA participants (n=7). .................................51

TABLE 4. CRNA attitudes toward computers (n=7) showing the number and % of respondents (in parentheses) by response item for each question. .................................................................52

TABLE 5. User satisfaction results from CRNAs after cognitive walkthrough. ...............................59

TABLE 6. CRNAs’ written comments on user satisfaction survey. ..................................................60

TABLE 7. Stakeholder interview responses (n=5). .............................................................................61
ABSTRACT

In 2001, the Institute of Medicine stated that one of the parameters needing to be addressed to improve health care was the creation of electronic health records for all patients. This goal has proven to be very challenging to health care providers. Many barriers exist that prevent the goal of computerizing health records such as high costs, usability problems, interface incompatibility, and fear of change.

The purpose of this feasibility project was to evaluate the usefulness and acceptability of a digital pen and paper (DPP) system for anesthesia documentation. The specific DPP technology used in this evaluation was a product developed by Shareable Ink®. Seven certified registered nurse anesthetists (CRNAs) evaluated the DPP system through a cognitive walkthrough procedure. During the cognitive walkthrough, the participants talked aloud as they carried out a series of anesthesia documentation tasks. Just prior to the cognitive walkthrough, participants were given a questionnaire that measured their perceived computer knowledge, attitudes and skills. After the cognitive walkthrough, a second questionnaire was used to determine their satisfaction with the DPP and their opinions about its usefulness for use in multiple anesthesia work settings.

In the second phase of the project, I interviewed other stakeholders in the hospital environment who would also be affected by implementation of a DPP system. This portion of the study was conducted at a community hospital without electronic record-keeping capability. Participation from several departments was sought via contact with hospital administration and department heads. Among those departments targeted for interviews were: Information Technology, Chief of Anesthesia, Anesthesia Billing, Medical Records and Nursing. Semi-
structured interviews were conducted and the responses of the participants recorded both as field notes and via audio recording.

This intent of this study was to test the feasibility of the digital pen and paper system for various types of anesthesia work environments by means of descriptive, survey and qualitative data analysis. Overall, the device was not only found to be usable by providers but also acceptable to stakeholders. Therefore, this device could be deemed a feasible solution toward implementing and adopting electronic documentation in some anesthesia work settings.
CHAPTER 1: INTRODUCTION

In the anesthesia environment, the hand-written anesthesia record has been the data collection tool of choice because it is easy to use and flexible. Using pen and paper, the provider records the data either by symbols, checklists, or notes on a one page form that can be carried from place to place by the anesthesia provider to record desired data when and how they wish. However, problems with the traditional documentation system are thought to have led to medical errors and poorer patient outcomes. Those problems often have stemmed from lack of timely access to patient information by all members of the healthcare team and legibility issues.

Since 2004, there has been a major impetus for creating national electronic health records (U.S Department of Health &Human Services, 2004). Even prior to 2004, two of the six aims for improving the quality of healthcare in the United States were to increase the timeliness and efficiency of retrieving patient data by permitting portability and accessibility of patient records (Institute of Medicine, 2001). Based on the report of the Institute of Medicine (IOM), the use of computerized charting is highly encouraged by the federal government. In fact, large monetary incentives to invest in information technology (IT) systems are underway. Subsequently, IT implementation, such as the electronic patient record, has been gaining momentum (Egger Halbeis, Epstein, Macario, Pearl & Grunwald, 2008).

Electronic anesthesia documentation systems can resolve problems with legibility and accessibility, but have limitations due to space requirements and their complexity to use in the anesthesia work environment. In this project, I explored the feasibility of a simpler electronic pen technology that may be adaptable for a variety of anesthesia settings.
Background and Significance

Historically, healthcare record-keeping has relied on the use of traditional pen and paper documentation, despite the fact that various types of computerized documentation systems have been available since the 1970s (Berner, Detmer, & Simborg, 2005). However, in the 1990s the Institute of Medicine (IOM) published a series of reports regarding patient safety and quality issues in the American healthcare system. The reports were highly critical of the way clinicians were communicating patient information via paper records. The IOM strongly recommended using computerized patient records (CPRs) to integrate and manage all clinical information about patients over their lifetime and various locations (IOM, 1991). The anticipated benefits of electronic records included a decrease in data replication, enhanced information, and improvement in information accuracy and accessibility that would, in turn, lead to improved clinical outcomes. It was also projected that a significant cost savings would result due to a decrease in the number of adverse reactions, a decreased need for record storage facilities, less staff time, and improved record review (Staggers, Thompson & Snyder-Halpern, 2001). More recently, several authors have suggested the need for electronic documentation as a means to gather data to advance evidence-based practice (Bakken, Cimino, & Hripcsak, 2004; Cooper, 2000).

The 1991 IOM report, To Err is Human, made public the fact that thousands of patients were dying each year due to preventable mistakes. In a subsequent report, Crossing the Quality Chasm, the IOM recommended ways to reinvent healthcare to foster innovation and improve delivery of care (IOM, 2001). Two principles highlighted in the report pinpointed ways to improve care with the use of medical information: (a) Patients should have access to all medical
information so that clinicians and patients can communicate effectively and (b) clinicians and institutions need to be able to exchange information regarding patient care to collaborate and coordinate care. The report also noted that problems identified with hand-written records, such as poorly organized patient information, and difficulty in retrieving records that were often illegible, could be eliminated through the use of electronic health records. However, the IOM recognized that, without a national commitment and financial support, a national health information initiative would make very slow progress (Berner et al., 2005).

In response to these reports, in 2004 President George Bush and Health & Human Services Secretary, Tommy Thompson, set a goal to computerize health records by the year 2014. Dr. David Brailer was appointed to direct this effort. In 2008, Congress enacted the Economic Stimulus Act, which permitted taxable deductions for the purchase of equipment needed to accomplish this goal (Towery, 2009). In 2009, President Obama extended this tax deduction to offset the expense involved in converting to electronic record-keeping systems and called for a $20 billion investment in health care technology (Anesthesia Business Consultants, 2009). President Obama also announced a government mandate to switch to electronic health records (EHRs) by 2016 or risk payment penalties (Towery, 2009).

Adoption rates of EHRs have been pathetically slow despite the projected benefits, the additional funding, and even the fear of forthcoming payment penalties. Even though potentially an EHR could improve quality, reduce errors and lower costs, these factors have not triggered enough motivation to overcome the resistance to EHR adoption (Berner et al., 2005). Swicki (1999) reported that only 11% of healthcare facilities had fully computerized systems, and only 32% had installed the necessary hardware and software. By 2006, only 11% of hospitals had
fully implemented an EHR, 57% had partially implemented an EHR and 32% had not yet started to do so (The Henry Kaiser Family Foundation, 2008). However, the situation is improving. A recent Healthcare Information and Management Systems Society (HIMSS) study reported that 43% of hospitals had at least adopted a computerized physician order entry system (Egger Halbeis, Epstein, Macario, Pearl & Grunwald, 2008).

Adoption rates for computerized anesthesia records are even more problematic. A popular term for a fully computerized anesthesia record system is an anesthesia information management system (AIMS). AIMS implementation rates are lower than those of hospital EHR implementation. In fact, the incidence of adoption is between 5-10%, with a somewhat higher (14%) adoption rate in academic health centers (Epstein, Vigoda & Feinstein, 2007; Egger Halbeis et al., 2008; Anesthesia Business Consultants, 2009; Cozad, 2009).

Many factors have contributed to the low number of AIMS installations. Among the 26 barriers identified by Egger Halbeis et al. (2008), the most common were cost, complexity of the systems to implement and use, quality issues, and legal concerns. Additional barriers included a steep learning curve, a problematic interface, fear of an increase in liability, and fear of not achieving a positive return on investment (Anesthesia Business Consultants, 2009). If the benefits attributed to an AIMS, such as automated data input, enhanced billing, improvements in compliance with regulatory agencies and a decrease in legal exposure are not realized or prove more challenging than the existing process of documentation, implementation may fail (Epstein et al., 2007).

A successful AIMS must strike a balance between convenience, legal, and regulatory requirements. A few studies have reported that AIMS promoted increases in denied billing,
accusations of fraud, Health Insurance Portability and Accountability Act (HIPAA) security sanctions, and difficulty defending against medical malpractice allegations (Epstein et al., 2007). However, others have found that an AIMS does not increase malpractice exposure (Feldman, 2004).

Other concerns to be overcome before the mass adoption of anesthesia information management systems is realized relate to problems with computerized records in general, such as lack of interoperability and data sharing between and within systems and problems within the work/organization environment such as physician and staff acceptance (Arvary, 1999; Despont-Gros, Landau, Rutschmann, Simon & Lovis, 2005). In addition, not just any computerized record-keeping system is acceptable by the federal government for electronic record-keeping. The federal government has set forth meaningful use criteria for electronic documentation systems that must be met to receive economic stimulus funding and future government payments for service (Blumenthal & Tavenner, 2010). These criteria are a set of fifteen core objectives that are considered the essential starting point for EHRs and a second set of important activities of which providers can choose five of the options to implement within the first two years (Blumenthal & Tavenner, 2010).

Numerous problems have been associated with fully computerized AIMS. For instance, existing computer technologies for documentation and data entry are problematic because these systems often rely on keyboard or mouse devices (Yen & Gorman, 2005). The preferred data tool in clinical settings continues to be the traditional pen and paper system because of its availability and ease of use. Other tools for data collection exist, but each has its limitations. For example, barcode systems do not support free text; speech recognition systems work well only if
restricted to a limited vocabulary; tablet personal computers (PCs) are limited by their weight and fragility; Personal Data Assistants (PDAs) are not easy to type on; and scanners incur a delay from document creation to input into the record (Yen & Gorman, 2005). Furthermore, scanned information cannot be easily accessed for research or quality endeavors because it lacks standardization and discrete data elements; consequently, the scanned file can only be treated as a single artifact (Huang, 2009). For these reasons, clinical data acquisition remains a challenge, especially in work environments with high cognitive workloads such as the anesthesia environment (Despont-Gros et al., 2009).

Of the AIMS that I have personally encountered, each has consisted of technology that will automatically collect some patient data, but requires other patient data to be entered via keyboard or mouse. In addition, the information usually has to be entered on more than one screen. Such systems are not only physically cumbersome in a small anesthesia work environment, but also require data entry methods that can either take the anesthetist away from the patient’s bedside or impede workflow. If an AIMS is not built into the anesthesia machine, the IT department has to configure brackets or carts to assemble the hardware and provide powering capability such as mobile workstations or extension cords for the system components. These designs make the equipment more apt to be damaged and also draw the provider away from overseeing the patient’s care. In situations of a critical or rapid nature, this entry system interrupts the workflow and potentially decreases vigilance. Many AIMS require scrolling through many screens to input or alter data which can also be disruptive. Every second spent staring at a computer terminal is time not spent observing the patient. Furthermore, fully
computerized systems require huge monetary investments, intensive training, and workflow adjustments.

In addition, a fully computerized record-keeping system can result in the automatic recording of spurious, unfavorable data or untimely data. It is not uncommon in anesthesia to have brief instances of aberrant vital signs for one reason or another. Most providers do not record aberrant data unless it is part of a trend (Feldman, 2004; Sanborn, Castro, Kuroda, & Thys, 1996). Under certain conditions, electrical interference can cause spurious data. These data are not recorded because rational decision-making by humans determines which data to be entered versus a computer sampling data indiscriminately (Feldman, 2004; Huang, 2009). There have also been litigated cases in which automatic data failed to record vital signs for an extended period of time (Huang, 2009). Finally, many clinical events require data to be recorded after the fact so that treatments can be given promptly. The anesthesia provider then must go back and review the automatic recording of data and append notations to explain unfavorable data, erroneous data, or any delay in recording of data.

Ensuring successful adoption of electronic documentation in anesthesia settings may require a system with features that mimic the familiar pen and paper system that is currently used in approximately 90-93% of anesthesia departments in the United States (Epstein, Vigoda, & Feinstein, 2007; Egger Halbeis et al., 2008; Anesthesia Business Consultants, 2009). An example of such a system is the digital pen and paper (DPP) system. The DPP system offers several potential advantages over elaborate fully computerized systems such as the capability of digitally capturing and storing hand-written patient data, providing paper backup, offering potential cost-savings and creating a very slight change in the normal work flow. The pen itself
is a digital camera that records the writing pattern on paper that contains an array of barely visible dots (Despont-Gros, Cohen, Rutschmann, Geissbuhler, and Lovis 2009; Yen & Gorman, 2005). The camera samples the position of the pen many times per second according to the coordinates determined from the dot matrix pattern. The pattern of dots permits each form to be uniquely identified which, in turn, makes it patient-specific (Despont-Gros et al., 2009). After the user completes the documentation record, the user downloads the data from the pen to the server (Despont-Gros et al., 2009). The user places the pen in a cradle that is then plugged in via a USB cable to download the data. Downloaded data from the pen is then entered into the patient’s electronic health record via an Internet server (Despont-Gros et al., 2009). One particular system, Shareable Ink® can perform tasks generally associated with fully computerized systems, such as conversion of handwritten data to typed data, completion reminders, organized storage of data, and automatic billing at time of service. Fully computerized systems have a host of positive characteristics, such as being paperless, possessing the ability to organize data, report all recorded data, and many associated add-on features. Yet, the low implementation rates of AIMS indicate there is a lack of acceptance of this type of system by anesthesia providers.

Any electronic documentation system has to appeal to all stakeholders involved with the implementation and use of a new information system. For the adoption of any electronic anesthesia documentation system to be deemed successful, the system must be compatible with existing information systems and workflow, user friendly, acceptable to government agencies, dependable and cost-effective. DPP technology may fulfill these requirements especially in those work environments unsuitable for implementation of a fully-computerized, keyboard entry documentation system. Research regarding the DPP’s usability and usefulness is limited. A few
authors have examined the use of DPP technology in the emergency room and on nursing inpatient units by nurses (Despont-Gros, et al., 2009. Dykes, Benoit, Chang, Gallagher, Li & Spurr, 2006; Yen & Gorman, 2005). The use of a DPP system also has been evaluated by anesthesia providers in a post-partum obstetric unit (Despont-Gros, Landau, Rutschman, Simon & Lovis (2005), but not in a busy surgical environment or off-site in a procedural room such as endoscopy.

**Purpose**

The purpose of this project was to test the feasibility of a DPP as an anesthesia information management system in common anesthesia work environments. To do so, nurse anesthetists were asked to evaluate a DPP system’s usability and usefulness for their practice during a cognitive walkthrough. Then input from other stakeholders regarding the DPP system’s interface, costs, and impact on patient care and mandate to fulfill government requirements was gathered to further analyze feasibility of the DPP system. The feasibility study addressed two questions:

1. How do nurse anesthetists rate the usability and usefulness of the digital pen and paper technology for documentation that they must conduct in their various anesthesia environments?

2. To what extent is the DPP technology acceptable to other key stakeholders within the hospital organization in terms of meeting documentation needs, interoperability, and costs?
Summary

EHRs have been on the horizon for a very long time. Most of the impetus for EHRs in the last 10 years has come from efforts by informaticists, the government, health care societies and private vendors. Implementation rates of EHRs continue to lag, particularly in anesthesia departments. The digital pen was suggested as a tool that could facilitate the adoption of electronic anesthesia documentation systems due to its ability to overcome known barriers to adoption such as a steep learning curve, high costs, and changes in workflow. The purpose of this project was to explore the feasibility of the digital pen as a documentation solution for nurse anesthetists and to ascertain stakeholder views regarding such a system in a hospital that had not yet implemented electronic anesthesia documentation.
CHAPTER 2: INTRODUCTION

This chapter summarizes literature from several disciplines to identify potential components of a conceptual framework to depict the elements and interactions that affect decision-making regarding technology within anesthesia care systems. Many theories have been developed to address successful technology adoption. An investigation of several were undertaken in order to better understand the key points necessary for technology adoption.

The resulting conceptual framework for this study was formulated from these technology adoption theories. This conceptual framework was used to structure a feasibility evaluation of a proposed new documentation system, the digital pen and paper electronic anesthesia record-keeping system. Existing DPP studies also were reviewed to provide foundational knowledge for this feasibility study.

Review of the Literature

Human Factors Engineering

Human factors engineering is concerned with studying human capabilities and limitations and applying that knowledge to design safe and effective products, processes, and systems to optimize human performance with that product or process (Boston-Fleischauer, 2008). It has been argued that the human conflict that often is created by technology implementation is due to the mechanistic view of the creators of the technology (Vicente, 2006). Specifically, designers too often focus on the hardware and software rather than on human needs and capabilities. For far too many years, system designers, system purchasers, and system implementers have acted with little to no input from the end-users. This, in turn, has led to implementation failures and financial losses.
A personal example of this kind of user-absent process was the purchase, for an anesthesia department, of an expensive rapid fluid infusion device that required assembly to use. The rapid infuser device was so infrequently used that no one knew how to assemble the parts. When an emergency fluid administration situation did occur practitioners used standard, simple pressure bags for rapid fluid administration assistance.

A better approach is to develop a system in conjunction with the end users so that it is compatible with their work environments. Vicente (2006) has envisioned this approach to technology adoption as a human-technology ladder. The first rung of the ladder is to design the physical technology to “fit” the human’s physical characteristics (e.g., in terms of size, shape). Once this is accomplished, the higher rungs of the ladder can be considered. These include fitting the technology to human psychological factors, team dynamics, organizational structure, and finally the political climate (Vicente, 2006).

Technologically sound systems may fail when designers build machines to perform tasks that they know little about (Vicente, 2006). Because most anesthesia providers are not in the business of designing AIMS, providers are often left having to pick the “right” system from those currently being marketed to their facility. To do this successfully, providers should take into consideration every “rung” of the human-technology ladder by using evaluation techniques that incorporate task analysis and user feedback (Vicente, 2006). Technology designs should fulfill a human or societal need by tailoring the design to specific relevant factors (Vicente, 2006). Thus any feasibility study will have to evaluate, not only the characteristics of the users, technology, task, environment, and organization, but also how these factors interact with each other. A number of socio-technical systems models have been developed to explain the
interactions between humans and technology in the workplace and how to develop joint optimization of the subsystems’ performance (Cartelli, 2007). In subsequent sections, a review of several of these theories will be described; but first, a review of the basic premises associated with the study of human-computer interaction (HCI) is provided.

**Human Computer Interaction**

Human Computer Interaction (HCI) is the study of how people design, implement and use computer systems, as well as how these systems affect the people involved (Staggers & Miller, 2001). Once a technological product has been conceived and a user population identified, the next step is to conduct an analysis of the user, environment, and task while using the technology (Johnson, Johnson & Zhang, 2005). HCI examines variables related to specific user characteristics, behaviors and computer actions when the users are carrying out a specific task within a particular context (Staggers, Kobus & Brown, 2005).

For HCI to be effective, three goals must be met: (a) Users must be involved early and steadily with the interface design; (b) the design process must be iterative and permit evaluation and correction of identified problems; and (c) formal evaluation with scientific research methods must take place (Staggers, 2003). Staggers & Parks (1993) synthesized these ideas as the Nurse-Computer Interaction (NCI) framework. The NCI framework depicts how nurses and computers exchange information within a multi-dimensional health care system. By knowing how information is exchanged between nurses and computers, optimization of processing the information can be evaluated. For instance, computerized medication ordering systems support an interaction between the order entry person and the pharmacy. In turn, the pharmacy interacts with the nurse who is dispensing the medications. The nurse in turn interacts with the patient and
records the medication in the patient’s electronic medication administration record. The model has proved to be useful for understanding these interactions and systems development. Elements lacking in this model include diversity in the work environment, systems evaluated post-development, and the user’s readiness for change. Still, the principles captured in NCI can help determine if an anesthesia provider’s interaction with a DPP system would fit with the anesthesia provider’s work flow and the task of documentation. However, because task completion is the focus, there is less emphasis on other elements of interaction such as the attitudes of anesthesia providers toward electronic documentation as well as the wide range of anesthesia providers’ technological competencies and anesthesia work environments. Perhaps other sociotechnical models are better at overcoming these limitations.

**Sociotechnical IT Models**

Human-Technology interaction principles have spawned several sociotechnical IT adoption models. The models were derived from theories that attempt to explain the ways in which organizational subsystems, humans and technology, interact together within organizations.

**The Information Success Model**

The Information Success (IS) model (DeLone & McLean, 1992) maintains that implementation success depends on actual usage of the system and user satisfaction with the system (Ammenwerth, Iller & Mahler, 2006). The IS model relies heavily on the quality of the IT system to determine its impact, but does not explain why the same IT system may be modified or rejected in other work settings (Ammenwerth et al., 2006). Before moving forward with an IT project, it is vital to test the system in all of the work environments expected to implement the system. Otherwise, providers may challenge the suitability of the system in the workplace, as
evidenced in the literature regarding the low adoption rates of fully computerized anesthesia record-keeping systems.

**The Technology Acceptance Model**

The Technology Acceptance Model (TAM) (Davis, 1993) explains why users adopt or reject a system using two constructs: “perceived usefulness” and “perceived ease of use.” These two constructs can predict end users’ attitudes toward using a system and consequently, the actual system’s use. Both constructs depend on features of the IT system. However, the model lacks an evaluation of: (a) IT systems involuntarily implemented; (b) extrinsic motivation factors; (c) user experience with the system; and (d) characteristics of tasks to be supported or the complexity of the tasks (Ammenwerth et al., 2006). By not evaluating these factors, implementation failure can result.

A perfect example occurred at a small private University. The IT department implemented a fully computerized testing center. The Colleges within the university were told that the old scanning system for test grading was being phased out in three months. Therefore, everyone converted to the new testing software system that was perceived to be useful and easy to use by the IT department. After a two hour campus-wide training program, the expectation was that everyone was adequately trained. However, after several months of problems with question formation, test creation, grading reports, shoddy technical support and system overloads, the faculty revolted. The faculty saw no “ease of use” or “usefulness” in this mandatorily implemented system. The university ultimately removed the testing system. This example confirms the necessity to test the DPP system in the workplace to determine if end users find it usable and suitable for the task. Technology purchases and implementation decisions that
fail to include usability testing or occur at just one organizational level may prove to be problematic and expensive for the organization.

Information Technology Adoption Model

In the Information Technology Adoption Model (ITAM) (Dixon, 1999), the term “fit” was used to highlight the need to match user knowledge to technical infrastructure (Ammenwerth et al., 2006). Dixon argued that perceived usefulness and perceived ease of use do not depend solely on system design features but also on the fit between user and system. However, like the Technology Acceptance Model, this theory does not address users’ extrinsic motivation to use the technology or the characteristics of the task (Ammenwerth et al., 2006).

In the case of anesthetic documentation, problems arise when the task of documenting care impedes anesthetic administration. For instance, one hospital assigned a CRNA fourteen cases of ten-minute duration. The primary task of providing care inhibits the ability of the provider to document care simultaneously. Nonetheless, care has to be documented for regulatory, legal, and financial purposes. A traditional pen and paper system permits the user to make quick notations with one hand. A fully computerized system with keyboard entry could be very problematic in this type of work setting. Therefore, systems that may work in a slower paced work environment may not work as well as in a fast-paced operating room. Furthermore, ITAM does not take into consideration changes in work environment that may alter the user’s value of the task or the quality of the task and, thus, the interaction with the information system. In anesthesia, a provider’s task of documenting care should never supersede the task of administering care, no matter what the extrinsic motivation for doing so may be. Therefore, during the consideration of a documentation system, these issues need to be addressed.
The Task Technology Fit (TTF) Model

Each of the preceding social-technology models emphasized a user’s individual knowledge and the quality of the technology, but neglected the clinical environment attributes and the clinical tasks to be supported (Ammenwerth et al., 2006). The Task Technology Fit (TTF) model (Goodhue & Thompson, 1995) takes into account the technology, user, and complexity of tasks that have to be supported by the IT system. The underlying principle is to determine the extent to which the functionality of the technology matches the task requirements and the individual user’s abilities (Ammenwerth et al., 2006). TTF concentrates on the fit between user and technology and between task and technology, but does not look at the interaction of user and task which may be necessary for successes in introducing an IT product. For example, as reported earlier, some anesthesia providers do not believe that it is important to document all vital sign data encountered during the course of an anesthetic for one reason or another. A fully computerized system could potentially document all vital sign events and any altered values as well. As a result, some anesthesia providers may believe that this automatic recording task is more of a problem than a useful capability of fully automated systems because it would take additional time to correct spurious data. This feature of a fully computerized AIMS documentation system could dissuade anesthesia providers from accepting the technology. In the end, anesthesia providers who do not value the automatic recording of data may want to maintain current documentation practices or adopt a system that would permit them to control data entry.

The Fit Between Individual Task Technology (FITT) Model

The FITT model was developed to characterize the fit between individuals, task & technology (Ammenwerth et al., 2006). According to FITT, IT adoption depends on the fit
between attributes of users (e.g., computer anxiety, motivation), attributes of technology (e.g., usability, functionality, performance), and attributes of the clinical tasks and processes (e.g., organization and task complexity). Of note, an individual is defined as either one user or a group of users. Tasks are jobs and processes that the user completes using the technology.

Organizational aspects to be considered are either part of the individual or part of the task (Ammenwerth et al., 2006). Finally, technology is defined as the interaction of various tools needed to accomplish a task. Although quite comprehensive, FITT does not address issues regarding the users’ or the organization’s readiness for change.

An organizational case in point is a contracted anesthesia group located in the Southwestern United States. The chief of a new anesthesia group, despite having inherited pre-existing installed computer hardware, balked at moving to an electronic anesthesia record. In the meantime, the hospital moved forward with computerizing patient records. It has been stated that the computer system implemented by the hospital does not possess an anesthesia package at this time. Therefore, the anesthesia documents are scanned into the patients’ EMR. Here is a case in point where the implemented system does not “fit” all groups in the organization and no motivation for change has been expressed. In the future, pressure from the federal government may stimulate interest and implementation of a system for anesthesia records, but nothing at this time has prompted the move to electronic anesthesia records.

The overall objective of IT implementation is an optimal fit between technology, user, environment and task. The task the system needs to accomplish must be defined and the IT system to perform the task must be compatible with the work environment. A conceptual model for evaluating human-computer interaction must address the crucial elements of user,
technology, task, environment and stakeholder. Yet, even when all these elements appear to fit together, one must consider organizational and user readiness for change and acceptability of an innovation.

Readiness for change impacts the ability to introduce technology in the workplace. Before moving forward with an IT project, there should be an assessment of the organization’s ability to support change (Gelmon & Droppers, 2008). To facilitate change suspension of disbelief that a new way can accomplish the task must occur (Varkey, Horne & Bennet, 2008).

When evaluating electronic record keeping systems, it is important to consider the physical nature of the workplace and workflow processes, the complexity entailed in learning to use the technology, and attitudes of both users and organizations regarding technological change. The importance of fit between user, technology, task, environment, and organization has been emphasized in multiple ways in the models described above. Therefore, a comprehensive model of interaction needs to acknowledge all of these elements. In addition, organizational commitment of the organization to change and accept an innovation should be evaluated. Principles from the Diffusion of Innovation theory by Rogers (1995) can address concerns regarding organizational acceptance of technology.

**Diffusion of Innovation (DOI) Theory**

Rogers (1995) theorized that certain perceived characteristics of innovations affect the rate of their adoption; and that stakeholders involved in decision-making roles regarding an innovation are classified by their behavior toward innovation. An innovation is defined as the first attempt to try an invention in practice with the aim of examining that invention’s value to the stakeholders (Varkey, Horne & Bennet, 2008). Individuals have five perceived concerns...
regarding innovations that affect the rate of adoption: (a) relative advantage, (b) compatibility, (c) complexity, (d) trialability and (e) observability (Rogers, 1995). DOI can provide guidance when looking at technology, task, and user variables embedded in a project, such as the qualities of the end-user, market, need for the project; as well as evaluations of a new system’s technical performance, cost and member acceptance. When introducing a new technology in the workplace, it is necessary to evaluate the acceptability of the technology by the organization’s stakeholders. DOI encompasses the issues involved with stakeholder acceptability of the innovation of the DPP system in this project. Interviewing stakeholders to ascertain needs and concerns prior to the introduction of technology will assist in determining the needs to be addressed in the design of a trial of an innovation or the decision not to trial the innovation.

A synopsis of the theories reviewed in this paper is presented as Table 1.

TABLE 1. Synopsis of technology adoption theories including key elements, strengths and potential weaknesses.

<table>
<thead>
<tr>
<th>Model</th>
<th>Elements</th>
<th>Strengths</th>
<th>Potential Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vicente</td>
<td>Human-tech ladder</td>
<td>Problems with Technology adoption stem from mechanistic view vs. humanistic view</td>
<td>One technology, many users-Needs may vary widely—how do you accommodate?</td>
</tr>
<tr>
<td>Staggers</td>
<td>Human-computer Interaction</td>
<td>Tech adoption needs user input, iterative design, scientific evaluation</td>
<td>One technology, many Environments -may vary widely—how do you accommodate? Stakeholders? Readiness for change?</td>
</tr>
<tr>
<td>IS</td>
<td>Information success relies on quality of technology</td>
<td>Links usage of system with user satisfaction</td>
<td>Why good in one setting and not in another?</td>
</tr>
<tr>
<td>TAM</td>
<td>Perceived usefulness Perceived ease of use</td>
<td>Acceptance comes from features of technology</td>
<td>What if involuntarily implemented?</td>
</tr>
<tr>
<td>Model</td>
<td>Elements</td>
<td>Strengths</td>
<td>Potential Weaknesses</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>-----------</td>
<td>----------------------</td>
</tr>
<tr>
<td>ITAM</td>
<td>Features of Technology to do task not enough</td>
<td>Need to look at fit between user and system not just features of system</td>
<td>Extrinsic motivation to change? Doesn’t consider that characteristics of task may change</td>
</tr>
<tr>
<td>TTF</td>
<td>Fit of technology with task</td>
<td>Technology and job performance</td>
<td>Doesn’t consider interaction between user and task and environmental concerns</td>
</tr>
<tr>
<td>FiTT</td>
<td>Attributes of user, technology, tasks and processes</td>
<td>Comprehensively evaluates user, technology, task and environment</td>
<td>Readiness for change not addressed</td>
</tr>
<tr>
<td>DOI</td>
<td>Diffusion of Innovation: relative advantage, compatibility, complexity, trialability &amp; observability</td>
<td>Technology acceptance comes from convincing people to adopt change</td>
<td></td>
</tr>
</tbody>
</table>

The Conceptual Framework for This Feasibility Study

Figure 1 depicts how user, task, technology, environment, and stakeholders of a system must fit together, much in the same way pieces of a puzzle fit to form a picture. Figure 1 also depicts the areas explored in this project. At the center of the model is the technology to be evaluated. In placing this piece in the middle, I am intending to indicate that the focus of this study is the technology, but as it affects the elements of each user in their unique work setting. In this study the technology under investigation, a DPP system, did not change. The task of documentation did not change, but was conducted under different time constraints. The elements of user, stakeholder, and environment did differ for each study participant. No specific relationships among the elements are hypothesized; the intent was simply to explore the various
elements that must fit together to achieve an acceptable solution for technology adoption in the workplace.

FIGURE 1. Conceptual framework for the feasibility study.
The conceptual framework was derived from the literature on human factors engineering, the Staggers & Parks human-computer interaction model, sociotechnical models and Rogers’ diffusion of innovation model. Anesthesia providers and anesthesia work environments present unique challenges to successfully implementing an electronic anesthesia record. The elements to be examined revolve around the interactions between technology with users, tasks, work environment and stakeholders. An evaluation of these interactions will then be used to determine the feasibility of a DPP system in the anesthesia work environment. In the following sections, each of the concepts in the model will be described in more detail.

Tasks

The first step involved in determining a health center’s IT needs consists of clearly defining the tasks the electronic health record should allow users to accomplish (Gelmon & Droppers, 2008). Figure 2 depicts, as a flowchart, universal anesthesia documentation tasks and associated concerns.

Environment

In addition to defining a task, the environments in which the task is to be accomplished need to be considered. Anesthesia environments are located anywhere a patient requires expert anesthetic drug administration or an expert anesthesia skill set (Figure 3). In each of these environments, constraints include time permitted for documentation, available lighting, need for strict vigilance (close patient observation), and patient acuity factors. These constraints may be problematic for achieving fully computerized documentation systems. For that reason, it will be necessary to consider a variety of anesthesia delivery settings in evaluating the feasibility of the DPP.
FIGURE 2. Diagram of anesthesia documentation tasks.
FIGURE 3. Constraints associated with anesthesia documentation tasks in various anesthetizing locations.

**Users**

Evaluation of the characteristics and behaviors of the users and how these might relate to the technology of interest is necessary. One of the greatest fears when introducing new technology or innovation is the potential for failure of the end-users to accept the new idea (Wolf, Greenhouse, Diamond, Fera & McCormick, 2006). If the users are not ready, willing and able to use the technology, the IT system will fail.

**Technology**

The technology of interest is a DPP system developed by Shareable Ink® (see Figure 4). In 2009, this product became commercially available. This DPP system electronically captures data entered by the provider. The encrypted data are uploaded to Shareable Ink® via the Internet server by way of a docking station. The data are checked for missing values, converted to text, organized, and distributed as appropriate to various stakeholders such as billing departments and
pharmacy and placed in the patient record. Changes in the anesthetist’s workflow from the current handwritten documentation procedure include making sure a pen is assigned to each provider and that all of a patient’s forms have the same dot matrix pattern. The provider then makes sure that the pen is docked for information download sometime after the patient is handed off in the post-anesthesia care unit. Another feature of this product is that if there are any interface problems between Shareable Ink® and existing EMRs, the company will work to help solve these problems (Huang, 2009).


Technology has to be functional and provide reliable performance in accomplishing a task. If the technology is too complex, or it interrupts work flow and requires significant change in work flow, or is incompatible with existing systems, the implementation may fail. The practice of anesthesia has become increasingly complex, potentially increasing anesthesia risk, due in part to the rapid development of technology (Webster, Stabile, & Merry, 2009). Implementing a complex documentation technology could further add to patient risk. Complexity issues affect all “rungs” of the human-technology ladder and impact the success or failure of the technology (Vicente, 2006). A less complex documentation system such as the DPP system could be advantageous in the complex anesthesia work environment. In the following section, findings from DPP research literature are reported.
Evidence Related to the Use of Digital Pen and Paper Technology

Several studies of the DPP system have been conducted, albeit with mixed results. Yen & Gorman (2005) compared the usability of a digital pen and paper system with that of a conventional pen for nursing documentation in a labor and delivery unit. Variables studied included the interaction of users, tool, task, and work environment (Yen & Gorman, 2005). A crossover design was used in which nurses used the digital pen either in the first or second half of the study and then used the conventional pen in the other half. Questionnaires were used to gather data regarding usefulness, ease of use, compatibility, and attitude. Interview data were examined via content analysis. The nurses demonstrated a statistically significant preference for the conventional pen. Themes generated from the interviews and observations included: (a) initial excitement, (b) successful adoption for routine use, (c) preference for conventional pen after honeymoon period and (d) too many adjustments needed to carry the bulky pen. Even though nurses initially had a positive attitude toward the DPP system, they ultimately rejected it due to usability problems. Factors not addressed in the study included data integrity, quality of character recognition and robustness of system during downtimes (Yen & Gorman, 2005). These results indicate that further research to evaluate the usability of DPP technology is needed.

By contrast, participants in a Swiss study found the DPP system to be both usable and useful (Despont-Gros et al, 2005). The prospective, unblinded observational study aimed at evaluating the use of DPP technology in two different clinical environments (an emergency room and an obstetric unit) and focused on user, task, and technology. The emergency room study aimed to evaluate user acceptance, and the obstetric unit study aimed to evaluate data acquisition reliability. No official training was provided to practitioners in either unit. It is worth noting that
pen specifications were built with users’ input prior to the study, unlike other studies involving this technology. The study itself included observations before and during the trial period and a satisfaction survey to evaluate perceived workload and characteristics, impact, acceptability and usability of the DPP (Despont-Gros et al, 2005). Other than the burden of capping this particular digital pen, users were satisfied with the technology because it required little adaptation, was easy to use, and did not waste their time (Despont-Gros, Landau, Rutschman, Simon & Lovis, 2005).

Dykes, Benoit, Chang, Gallagher, Li & Spurr (2006) conducted a prospective interventional study regarding the feasibility of the digital pen and paper system to capture vital sign data in an acute care setting as a bridge to a fully automated system. The study addressed many of the usability issues determined to be problematic by Yen & Gorman before implementing a DPP system. Problems with carrying an extra pen were addressed by attaching the pen to lanyards and strategically placing docking stations in the nursing unit. However, a number of problems with the DPP system were observed, including hardware and software issues, system downtime, and data acquisition issues that led to workflow problems. Also, problems occurred with data uploads and timing of the vital sign recording. As a result of these problems, the DPP system was determined not to be a feasible bridge technology (Dykes et al., 2006). Still, the authors reported a 91.9% accuracy rate in data acquisition and an upward trend in user satisfaction with the DPP system due to its capability for providing improved vital sign data access and the friendly work-flow operation. However, because data needed to be verified before uploading, it was deemed too burdensome in an acute care setting. Once again, the usability of the DPP system was called into question because the technology did not fit the user.
Several DPP systems have been evaluated in the literature. Usability was the most discussed issue in these studies. Usability measures include ease of use, user satisfaction, efficiency of use, error free/error-forgiving interactions with the fit of an application to the task and user (Staggers & Miller, 2001). Kushniruk & Patel (2004) define usability as the capacity of a system to permit users to carry out their tasks safely, effectively, efficiently, and enjoyably (Kushniruk & Patel, 2004). Three issues related to usability are user-friendliness, user competence, and user confidence (Demiris, Afrin, Speedie, Courtney, Sondhi, Vimarlund, et al., 2008).

The DPP system was chosen as a potential electronic anesthesia documentation system based on its ability to mimic the current pen and paper task of documentation and record medical information digitally. The DPP system is not as elaborate as some of the AIMS systems on the market. Because the system does offer less complexity and more flexibility, it is potentially more user-friendly and subsequently more user acceptable than other AIMS available.

Stakeholders

The last element in the framework is the stakeholder. For this study, stakeholders are defined as non end-users who have a vested interest in the technology. For this project, the other stakeholders included workers in the IT, billing, medical record, and nursing departments as well as the head of the anesthesia department.

Summary

This chapter has described the conceptual framework for a feasibility study concerned with the use of DPP technology in the practice of anesthesia. The literature review revealed several theories developed for use in explaining human-technology interaction. A feasibility
evaluation should include an analysis of how users, tasks, technology, work environments and stakeholders fit together and affect the ability to launch a technological change such as a DPP system. All in all, success of incorporating IT in health care will occur when IT systems are considered necessary devices to provide health care (Tyler, 2009). To achieve this goal requires: (a) user centered designs that permit minimal effort and maximum effectiveness for the end user, and (b) a design process that permits correction of identified problems (Rubin, 1994). In the few available DPP technology studies, mixed results have been reported regarding the usability of the DPP system on nursing units. Unfortunately, the views of stakeholders other than the users were not reported in any of these studies. Consequently, a usability evaluation of the elements of task, technology, user, and environment for anesthesia providers coupled with an evaluation of stakeholder needs and concerns regarding the DPP system were the two purposes of this study. In the next chapter, the methods to be employed for this feasibility project are outlined.
CHAPTER 3: INTRODUCTION

The goal of the feasibility study was to assess the relative advantage, compatibility, and complexity of the DPP system by studying the interaction of the task, technology, environment, and user elements as described in the conceptual framework. Usability engineering principles were used in this project to assess the viability of a DPP system within user-specified anesthesia work environments. This method’s underlying premise is that the process of design and evaluation are highly interrelated so that the needs and limitations of the end user take precedence over the preconceived user requirements as determined by the designers (Kushniruk & Patel, 2004). The high failure rate of IT systems has been attributed to the lack of user-developed, iterative designs (Johnson, Johnson & Zhang, 2005). Ideally, getting end-users involved early in a system’s design and development phases will help create a final product which is more acceptable to the end-user. Consequently, products developed without end-user input would at least require end-user input evaluation of the product in the workplace prior to implementation. Implementation planners need to remember the importance of the relationship between development of a system and the clinical workflow in which the system will be expected to function (Varkey, Horne, & Bennett, 2008). In anesthesia, individuals and tasks can be rather different from setting to setting, which requires a high degree of flexibility of the IT system and end-user. As a result, before the purchase and implementation of an IT system, it is necessary to take into account the fit between the work environment, user characteristics, and the innovation itself.

The feasibility study consisted of two parts. The first part was a usability evaluation of the DPP technology which took the form of a cognitive walkthrough by potential end users. The
second part entailed interviewing other stakeholders in a health care system that could be impacted by a conversion to a DPP documentation system. These data were then used to evaluate the overall acceptability of the DPP system in an anesthesia work environment currently without existing electronic anesthesia documentation capability. The methods used for each part of the study will be described separately.

**Methods**

**Cognitive Walkthrough**

**Sample and Setting**

The population of interest was comprised of certified registered nurse anesthetists. A recruitment campaign was launched by email and letter writing to CRNA providers in Phoenix, Arizona. A convenience sample of approximately 7-10 CRNA providers was desired for participation in the cognitive walkthrough. Seven CRNAs were recruited. Each participant’s cognitive walkthrough took place at their location of choice, provided it was conducted in a private and quiet environment.

**Design and Procedures**

After being introduced to the study and reading and signing the informed consent document, each participant was asked to complete a questionnaire. The questionnaire was used to assess the participant’s occupational background, computer knowledge, perception of their personal computer skills and attitudes regarding their use of technology at home and at work (Appendix A). As part of a cognitive walkthrough, one must define the profiles of the users, their knowledge of the task, and the technology (Abowd, 1995). An evaluation of user characteristics (attitudes, skills, knowledge related to technology) was used to describe the CRNA providers
Taking part in the evaluation because background, experience or technical knowledge may influence users when they attempt to deal with new technology (Usability Inspection: Cognitive walkthrough, n.d.).

After completing the questionnaire, the cognitive walkthrough was initiated. A usability method known as the cognitive walkthrough was used to determine if a DPP system “fits” with the perioperative anesthesia work environment. Cognitive walkthrough is a review technique involving one or a group of evaluators or participants inspecting a user interface by role playing a set of tasks that focus on learning through exploration (Usability inspection: cognitive walkthrough, n.d.; Abowd, 1995). In a cognitive walkthrough representative users think about the step-by-step process of using a system when they are performing representative tasks. The task selected for the evaluation was completion of an anesthesia record. Cognitive walkthrough was chosen as the evaluation tool for this study as it is a proven technique in usability engineering; it enables uniform testing of participants, and is easier to execute this type of evaluation in an artificial environment versus the clinical setting, which would have required multiple permissions and interruptions of workflow. In this cognitive walkthrough, the participants used the DPP system to complete a predefined set of documentation tasks that are normally associated with anesthesia care delivery in two different settings (Appendix B). Both cognitive walkthrough exercises began with a patient interview and ended with the participant completing the PACU notes. Two walkthroughs were conducted. In the first walkthrough, there was no time limit. In the second walkthrough, the participants were asked to envision using the DPP system in an anesthesia environment that was familiar to them other than the operating room. The participants were given five minutes to complete the documentation task. The
participants were given documentation forms produced by Shareable Ink® for charting purposes. The participants were asked to record on these forms realistic, but simulated data that was either provided to them by me or individually determined by the participants, such as vital signs and drug dosages. The participants were given the pen to hold, carry, and use as it would be used in performing normal day-to-day anesthesia documentation tasks. While the participants were using the DPP system, they were asked to talk aloud about their experience. During the walkthroughs, I recorded observational data regarding the action sequences required for completing the tasks. Additionally, audio recordings were made of the data collected as participants spoke about their experience (Appendix E). My observations focused on the participants’ success in performing typical anesthesia-related documentation tasks with the trial Shareable Ink® DPP system (Appendix B provides an outline for the observations). Answers given to open-ended questions regarding the potential advantages and disadvantages of using the DPP system in those environments were also audio recorded (Appendix E).

Finally, participants were asked to complete a second questionnaire about their overall user satisfaction with the DPP system for anesthesia documentation (Appendix C). During the session, all of the written data that was collected was verified verbally with each participant.

**Instrumentation**

The precognitive walkthrough questionnaire (Appendix A) was adapted from two well-tested data collection tools developed by Balen & Jewesson (2004) and McLane (2005). The items selected represented six domains: demographics, computer experience, computer anxiety, basic computer skills, anticipated computer needs, and attitudes toward technology.
The open-ended cognitive walkthrough interview questions were analyzed to gather data from the participants regarding their experience with the DPP system and opinions about using the DPP system in locations outside of the operating room. These questions were adapted from the work of Wharton, Rieman, Lewis & Polson (1994).

For the post-trial questionnaire (Appendix C), I purchased the rights to adapt the Questionnaire for User Satisfaction (QUIS), a well-tested user satisfaction tool developed at the University of Maryland (Chin, Diehl & Norman, 1988). The 17-item questionnaire solicited participants’ opinions about the usefulness and usability of the DPP system.

Data Analysis

The pre-study questionnaire included both closed-ended and open-ended questions. Descriptive analysis and thematic content analysis to identify themes within the data were performed. The post-trial satisfaction questionnaire contained Likert scale data and some open ended questions, thus, simple descriptive analysis and theme analysis was employed here as well. All relevant observational data and transcribed audio data were analyzed by means of thematic content analysis. Comments such as instructions and personal conversation were excluded from the analysis.

Stakeholder Analysis

Setting and Sample

The second part of the feasibility study focused on the opinions of key stakeholders other than nurse anesthetists. This evaluation took place at a hospital currently without electronic anesthesia documentation capability. The hospital was asked to supply the name of a contact person from each of the five departments that may be affected by electronic documentation. The
stakeholders interviewed included the chief of anesthesia, an information technology representative, a representative of the anesthesia billing department, medical records staff, and perioperative nursing staff.

**Design and Procedures**

After obtaining informed consent, I conducted a semi-structured interview with each stakeholder participant. The interview began with questions regarding the participant’s familiarity with DPP systems and their opinions about electronic documentation systems in general (Appendix D). Next, I introduced each participant to the Shareable Ink® DPP system. I provided a short demonstration of the DPP system to familiarize the stakeholders with this technology. Following the demonstration, the interview continued with questions about the feasibility of this DPP system from their professional viewpoint. Interviews were audio taped to ensure accurate data collection.

**Data Analysis Plan**

Audio taped responses were transcribed verbatim and pertinent comments were analyzed thematically. Results are found in Chapter 4.

**Data Management Plan**

All electronic data were kept on my computer after downloading and protected by a password. All other written and audio data was stored in a locked filing cabinet at Midwestern University.

**Human Subjects’ Protection Plan**

IRB approval was obtained from the University of Arizona, and approval was granted from the community hospital as an exempt study. Participants were assigned a code number on
the digital recorder and asked to complete an informed consent form because of the audio recording. No individual identifiers were used in any of the reports.

**Summary**

This chapter outlined the methods used for sample selection, data collection, data analysis, and data security. In the following chapter, the findings of the study are reported to answer the two proposed questions of the study regarding usability and acceptability.
CHAPTER 4: RESULTS

Introduction

This chapter presents the results of the study. First, the results of the cognitive walkthrough are reported, followed by the results of interviews with the other hospital stakeholders who may be affected by implementing a DPP system.

Results of Cognitive Walkthrough

Description of the Sample

Ninety-one invitations to participate in this project were sent to Phoenix area CRNAs in January 2011 following IRB approval for the study by the University of Arizona. Seven CRNAs volunteered to participate, which met the minimum number of participants needed for the desired sample size. The group consisted of four females and three males, which mimics the current national gender split for CRNAs (www.aana.com, 2011). Five CRNAs are currently working full-time, one had retired and one was employed part-time. Years of CRNA experience ranged from 1 year to more than 15 years. Thus, the sample was comprised largely of either relatively novice or highly experienced CRNAs. The majority (57%) worked 25-40 hours per week.

<table>
<thead>
<tr>
<th>Years Experience</th>
<th>Number Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 years</td>
<td>3</td>
</tr>
<tr>
<td>6-10 years</td>
<td>0</td>
</tr>
<tr>
<td>11-15 years</td>
<td>1</td>
</tr>
<tr>
<td>&gt;15 years</td>
<td>3</td>
</tr>
</tbody>
</table>
TABLE 3. Worked hours per week reported by the CRNA participants (n=7).

<table>
<thead>
<tr>
<th>Hours worked per week</th>
<th>Number Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>1</td>
</tr>
<tr>
<td>10-24</td>
<td>1</td>
</tr>
<tr>
<td>25-40</td>
<td>4</td>
</tr>
<tr>
<td>&gt;40</td>
<td>1</td>
</tr>
</tbody>
</table>

All participants had a computer at home, but 71% had never received any formal computer training. All participants reported that computers were readily available at work. Most (71%) did not currently use an electronic/computerized anesthesia record, but 57% had used a computer for some task at work in the past. Most (83%) participants spent 6-10 hours a week on the computer at home, while 57% spent 1 to 5 hours per week using the computer at work. All participants had used a computer at work to access patient laboratory results, and 71% had entered an order using a computer system. All participants believed they were highly functioning with computers but could use some additional training. None felt the need to upgrade their computer skills to improve their job effectiveness. In addition to self-reported demographic data, CRNA attitudes toward computers were evaluated by means of the precognitive walkthrough survey (Table 4).
TABLE 4. CRNA attitudes toward computers (n=7) showing the number and % of respondents (in parentheses) by response item for each question.

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers reduce need for boring tasks</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Computers help improve care</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Monitoring of care by government and third party increases with computers</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Patient confidentiality is at increased risk with computers</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Computer use adds to anesthesia workload</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I look forward to implementing a computerized anesthesia record</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Very Unimportant</th>
<th>Somewhat Unimportant</th>
<th>Somewhat Important</th>
<th>Very Important</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>More accurate computer reports are:</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Computers for anesthesia documentation are:</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>More accurate computer reports are:</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Computers for anesthesia documentation are:</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Respondents viewed computers as capable of reducing the need to carry out boring tasks and as leading to improved patient care. Four CRNAs looked forward to implementing a computerized anesthesia record. In addition, nearly all CRNAs reported that more accurate
computer reports and computer documentation were at least somewhat important. However, just over half of the CRNAs felt that computers decreased patient confidentiality; and most thought that computerized documentation added to the anesthesia workload. Nearly all believed that monitoring by the government and third party agencies also increases with the use of computers.

Based on these survey results, all seven CRNAs demonstrated that they had sufficient computer and anesthesia knowledge, computer and anesthesia experience, and physical ability to participate in this cognitive walkthrough.

**Thematic Analysis**

Two major themes and two subthemes emerged from the analysis of the data captured from the audio recordings. The major themes were perceived ease of use and perceived usefulness. Reliability and user control emerged from the data as subthemes of perceived usefulness, as shown in Appendix E.

**Perceived Ease of Use**

CRNAs were generally happy with the simplicity of the DPP system. Although pen size pleased some, others considered it a limitation. “Bulky” was the term used by all participants to describe the pen, although sometimes “bulky” was viewed by some as making the pen easier to grip. Several CRNAs voiced concerns regarding the “durability” of the pen, “loss of the pen” and questioning how “easy it would be to carry the digital pen.”

Three participants spoke of the DPP system as “being good for older anesthesia providers” because it required almost “no change in work flow” and “good for older practitioners due to mental block with computers.” The most experienced CRNA of the group commented that “I will not be using this [DPP system].” This provider had used a fully computerized system with
built in “macros” that eliminated “duplication” and was “easier than writing.” On the other hand, another experienced CRNA currently using a fully computerized system stated that it was nice not to have “one more computer screen to look at” and that the provider’s current computerized system was “painful to use.” This provider then stated that the DPP system “was better than their current computer system.”

Based on my observations, the CRNAs appeared to be baffled by the anesthesia record form that was used to record the anesthetic information in this exercise. During the first scenario, all of the participants spent more time trying to determine where to place the data rather than actually inputting the data. This was not as problematic during the second time-limited scenario. Once the CRNAs understood the form, they could operate the device smoothly and efficiently; although some commented that the pen was “bulky” (as noted earlier) and they “had to press hard” to write. I noted that the CRNAs generally placed the cap on the table next to the anesthesia form rather than on the pen, but only one CRNA mentioned that it would be “easy to misplace the cap.” Last, some of the CRNAs had difficulty in figuring out how to dock the pen. Many wanted to re-cap the pen or put the pen in backwards, but quickly recognized their mistake.

**Perceived Usefulness**

Comments about the usefulness of the DPP system were both positive and negative. On the positive side, five of the CRNAs commented that the DPP system mimicked their current documentation protocol of using a traditional pen and paper system. Many commented that there would be “no change in workflow” and “I am used to pen and paper—so no change for me.” Furthermore, the CRNAs noted that “our docs don’t want to be part of any computer and have to
be computer certified” and that “locums [traveling CRNAs] could come in and use [this system] the [first] day of work—not with our fully computerized system—they would have to be trained.”

Other applications of the DPP system received praise as well. CRNAs commented that: (a) “Analytics were really neat,” (b) “Lots of statistics can be run with this device,” (c) “I like the transition to text that it does—really cleans it up,” and (d) “Can do billing with this?” Comments about using the DPP system in a rapid turnover environment ranged from “good” to “Hospital computers are usually slow to download—might slow things down.”

Participants voiced negative views about the potential usefulness of the DPP as well. The number of pens that would have to be purchased was a concern. Participants asked questions such as: “What if [we] lose [the] pen? Is it expensive?” and “Can you re-assign the pen every day to more than one person?” Additionally, the participants voiced concerns about security of patient data, time required to correct errors on the anesthesia record, and making the paper record an electronic record. In regard to security, comments included: “Computer systems can only be accessed with usernames and passwords—[therefore] increased security” and “Security could be an issue with any computer system—I am not worried about this--have to figure [it] out.”

Regarding the time needed to correct errors, one CRNA commented that “People will not be likely to fix charts if the charts leave the periop area” and “So you download pen in PACU if you have time”? Questions and comments regarding the DPP’s electronic capability included: (a) “Does it integrate with preexisting charts”? (b) “Doctors will never scan records into chart; they will have a secretary do it”; and (c) “So this is not an actual computerized record until it is docked?”
In summary, perceived usefulness comments varied a great deal, ranging from “This is light years ahead of ... what they are trying to implement on us--Send the rep my way” to “I am used to a computer.” Two subthemes emerged related to perceived usefulness. These two subthemes were: (a) the reliability of the DPP system and (b) the user’s ability to control the values entered via the DPP system.

Reliability

The participants commented extensively about the reliability of the DPP system. Statements expressing dissatisfaction with the reliability of the DPP system were more frequent than those expressing satisfaction. Positive comments included the following: “Good to have paper backup if computer fails;” “We train our users how to go to paper backup if our system fails, [but] this system is a paper backup;” and “Downloaded fast this time.” Participants identified two major areas of dissatisfaction: (a) accuracy of the handwriting recognition, and (b) the functioning of the system. Handwriting recognition concerns expressed, included comments such as: (a) “It’s not recognizing my handwriting, and I have good handwriting;” (b) “Would rather not change data to text;” (c) “Seems to be good with numbers but trouble with words;” (d) “Every record needs correcting;” (e)“Can’t read my own writing sometimes;” (f)“Looks like you still need someone to review the record for accuracy;” (g) “I could see docs forgetting their pen and coming in an asking me to use my pen—then information is recorded in my name;” and (h) “my penmanship would have to improve.”

Functional concerns noted by participants included: (a) “How long does the ink last?” (b) “If you only fix record on computer and not written one—could have conflict; (c) “Looks like your server is down when try to download—makes me skeptical--we hear that now with our
computer system;” (d) “Pen was not charged during first attempt at cognitive walkthrough—no electronic data—just paper data—obviously an issue;” and (e) “Who will make sure pen is charged for use? With Vocera we just pick up a fresh battery.”

**User Control of Data Entry**

This subtheme emerged from the comments made by several of the participants who viewed the DPP system more positively because it permitted the user to control the data entry. Statements noted to be supportive of this capability included: (a) “It only records data I input-SOLD!! I do not like computer telling me that the patient is in sinus rhythm—when it isn’t—interference recorded a problem—only reason I have been hesitant to accept computerized charting;” (b) “I don’t like any vital signs charted for me;” (c) “We cannot edit vital signs on our records—just drugs, events and write addendums so if line is kinked and looks like patient isn’t breathing it gets recorded and we have to write a note;” and (d) “I don’t want all data recorded like a computer system may do—because artifact and false data doesn’t need to be on a chart—I can choose.” Comments opposing this feature included: (a) “Text feature could be a liability if information interpreted incorrectly,” (b) “My system automatically records vital signs and we cannot leave the OR if our record is not complete,” and (c) “my penmanship would have to improve.”

**Observational Data**

In addition to problems with working with the form, the CRNAs asked many questions about the technology, which resulted in considerable dialogue between the participants and myself. Notably, the novice CRNAs were no different in their performance nor were they less apt to ask questions than the veteran CRNAs. The five minute time limit for the second trial did
not impair the process of performing the task, but a few of the participants wanted to continue to write in order to avoid error messages after docking.

**User Satisfaction Survey Results**

The last task for the CRNAs was to complete a user satisfaction survey regarding their trial of the DPP system. Table 5 summarizes the results, showing negative responses on the left side of the table and more positive responses to the right. The number of actual user responses is shown in bold typeface below each response scale.

Positive comments were scored as 6 or better and negative comments were scored as less than 5. A score of 5 was considered neutral. Overall, out of a possible 119 responses, 118 responses were collected. Ninety-four responses were recorded as 6 or better. One participant consistently rated the pen as negative in all categories except for items regarding ease of learning/use and speed of system. Other participants rated the system either positively or as neutral in all but one category. Correcting typographical errors was noted by an additional participant to be difficult.

Only a few comments were offered by the participants (Table 6). Responses reflected that the DPP was easy to learn to use, but that the handwriting technology needed to be improved, that the system was archaic compared to some computer anesthesia records, and that accuracy may be an issue.
TABLE 5. User satisfaction results from CRNAs after cognitive walkthrough.

<table>
<thead>
<tr>
<th>Overall Reaction to pen</th>
<th>1=Terrible</th>
<th>2 3 4 5 6 7 8 9=Wonderful</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1=Frustrating</td>
<td>2 3 4 5 6 7 8 9=Satisfying</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>1=Difficult</td>
<td>2 3 4 5 6 7 8 9=Easy</td>
<td>NA</td>
</tr>
<tr>
<td>Characters on Screen were</td>
<td>1=Hard to read</td>
<td>2 3 4 5 6 7 8 9=Easy to read</td>
<td>NA</td>
</tr>
<tr>
<td>Learning to operate pen was:</td>
<td>1=Difficult</td>
<td>2 3 4 5 6 7 8 9=Easy</td>
<td>NA</td>
</tr>
<tr>
<td>Exploration of features by trial and error were:</td>
<td>1=Discouraging</td>
<td>2 3 4 5 6 7 8 9=Encouraging</td>
<td>NA</td>
</tr>
<tr>
<td>Remembering names and uses of commands was:</td>
<td>1=Difficult</td>
<td>2 3 4 5 6 7 8 9=Easy</td>
<td>NA</td>
</tr>
<tr>
<td>Tasks can be performed in a straightforward manner</td>
<td>1=Never</td>
<td>2 3 4 5 6 7 8 9=Always</td>
<td>NA</td>
</tr>
<tr>
<td>System speed to upload was:</td>
<td>1=Too slow</td>
<td>2 3 4 5 6 7 8 9=Fast enough</td>
<td>NA</td>
</tr>
<tr>
<td>Response time from server was</td>
<td>1=Too slow</td>
<td>2 3 4 5 6 7 8 9=Fast enough</td>
<td>NA</td>
</tr>
<tr>
<td>Rate downloaded information is displayed</td>
<td>1=Too slow</td>
<td>2 3 4 5 6 7 8 9=Fast enough</td>
<td>NA</td>
</tr>
<tr>
<td>The system is reliable</td>
<td>1=Never</td>
<td>2 3 4 5 6 7 8 9=Always</td>
<td>NA</td>
</tr>
<tr>
<td>The system warns you about potential problems</td>
<td>1=Never</td>
<td>2 3 4 5 6 7 8 9=Always</td>
<td>NA</td>
</tr>
<tr>
<td>Correcting your mistakes was:</td>
<td>1=Difficult</td>
<td>2 3 4 5 6 7 8 9=Easy</td>
<td>NA</td>
</tr>
<tr>
<td>Correcting typos were:</td>
<td>1=Difficult</td>
<td>2 3 4 5 6 7 8 9=Easy</td>
<td>NA</td>
</tr>
<tr>
<td>Ability to undo operations was:</td>
<td>1=Difficult</td>
<td>2 3 4 5 6 7 8 9=Easy</td>
<td>NA</td>
</tr>
<tr>
<td>Ease of operations depends on your level of experience</td>
<td>1=Never</td>
<td>2 3 4 5 6 7 8 9=Always</td>
<td>NA</td>
</tr>
</tbody>
</table>

Negative Comments | 1 2 3 4 5 6 7 8 9=NA

Positive Comments

| Sum | 1 2 3 4 5 6 7 8 9=36 | 2 1 1 1 2 | 1 |
TABLE 6. CRNAs’ written comments on user satisfaction survey.

<table>
<thead>
<tr>
<th>Positive comments</th>
<th>Negative comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to learn</td>
<td>Archaic</td>
</tr>
<tr>
<td></td>
<td>Concerned with handwriting technology</td>
</tr>
<tr>
<td></td>
<td>Would rather use drop down menus and macros</td>
</tr>
<tr>
<td></td>
<td>Mark within lines or get false readings</td>
</tr>
</tbody>
</table>

Results of the Stakeholder Interviews

After a brief demonstration of the DPP system, likely non-end-user stakeholders in one hospital commented on potential applications of the DPP system in their work environment. The respondents included the Chief of Anesthesia, the Director of Information Technology, a PACU nurse, the anesthesia bill organizer, and the Assistant Director of Medical Records. The interviews consisted of the following four questions:

1. What are your top three concerns when thinking about implementing an electronic anesthesia record-keeping system?
2. Have you heard or worked with a digital pen product in the past?
3. What applications do you see for the digital pen system in this hospital?
4. Would you have any concerns about implementing this digital pen system?

These interview questions were developed to gather specific concerns of individual stakeholders based on their particular job expertise. Stakeholder responses were recorded via a digital recorder. The recordings were transcribed verbatim for purposes of analysis. Table 7 details the responses from the stakeholder interviews.
TABLE 7. Stakeholder interview responses (n=5).

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Top concerns about computer records</th>
<th>Heard of DPP?</th>
<th>Possible Applications for DPP</th>
<th>Concerns with DPP system</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1) Down time on computer&lt;br&gt;2) lack of expertise with computer&lt;br&gt;3) automatic recording of events that may be in error i.e. BPs</td>
<td>no</td>
<td>good for picking up missing data in charts and billing, easy to learn if “moonlighting”</td>
<td>Durable? Learning curve;</td>
</tr>
<tr>
<td>#2</td>
<td>1) patient information is secure&lt;br&gt;2) ease of use for training purposes&lt;br&gt;3) maintenance</td>
<td>yes</td>
<td>besides anesthesia any provider that prefers writing as an input mode, older folks, nurses, infrastructure, does every provider need to have a pen? How do I keep then charged? Warranty? Network standpoint should be okay</td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>1) time frame involved with using the pen&lt;br&gt;2) Ability to correct errors&lt;br&gt;3) Confidentiality of patient record</td>
<td>yes</td>
<td>All aspects—PAT especially, is there a DC planning feature?</td>
<td>Durable? Learning curve</td>
</tr>
<tr>
<td>#4</td>
<td>1) Concern with input by CRNAs-is it checked for errors?&lt;br&gt;2) make sure correct patient&lt;br&gt;3) may not have a job</td>
<td>no</td>
<td>good for anesthesia billing, not good for OR supplies</td>
<td>None</td>
</tr>
<tr>
<td>#5</td>
<td>1) every provider has access&lt;br&gt;2) make sure providers understand importance of documentation&lt;br&gt;3) sufficient training</td>
<td>no</td>
<td>OR, Anesthesia, Pain mgmt center, Endo</td>
<td>None</td>
</tr>
</tbody>
</table>
All stakeholders appeared to be intrigued with the DPP system. The stakeholders mentioned concerns similar to the CRNAs in that they wanted to make sure the system was easy to learn, easy to use, and reliable. The stakeholders appeared to be more cognizant of security issues, maintenance issues, and warning or reminder systems to assist the provider in completing the record. Of note, cost associated with computer records was not mentioned, even though it was one topic that I had anticipated finding with this group.

Summary

This chapter summarized the results of the feasibility study. The data collected were intended to quantitatively measure and qualitatively examine the usefulness and acceptability of a DPP system to both providers and stakeholders within the perioperative environment. The pre- and posttest surveys were used to capture data about the CRNA providers evaluating the DPP device. Furthermore, the cognitive walkthrough was used to capture audio and observational data as the CRNA providers evaluated the DPP system by way of hands on experience. Interview data from other hospital stakeholders were needed because they would be affected by the implementation of the DPP system and they could affect the ability to change the current anesthesia documentation system used in this hospital.
CHAPTER 5: DISCUSSION OF RESULTS

Introduction

The purpose of this chapter is to synthesize meaning from the results of the data collection. Theories from human factors engineering, human computer interaction, sociotechnical models, and diffusion of innovation were used to develop a systematic approach to data collection that enabled me to evaluate the feasibility of a DPP system for accomplishing electronic anesthesia record-keeping. In turn, these theories lend themselves to the discussion of the results obtained.

Summary of the Study

This study was designed to examine the feasibility of using a digital pen and paper system as a way to overcome some, if not all, of the problems listed above. The study therefore consisted of two parts. The aim of the first part of the study was to gather written, observational and verbal data from CRNA anesthesia providers about the usability of a DPP system via a cognitive walkthrough and their satisfaction with the DPP system by means of an adapted survey tool. In addition, demographic data and data about each participant’s computer background and preconceived attitudes about computer use were collected to describe the characteristics of the sample taking part in the study. The aim of the second part of the study was to determine the acceptability of a DPP system by interviewing a group of stakeholders within a hospital system who could be affected should a digital pen and paper electronic anesthesia record system be implemented in their hospital.

The ability to convert anesthesia practitioners from paper and pencil documentation to a computer system has been a struggle. Users want a user-friendly, time efficient, cost-effective,
reliable, and secure system. Hence, the idea that a system that more closely mimics current pen and paper documentation may be the key to improving the rate of adoption of electronic health records among anesthesia providers.

Many technology interaction theories address the problems inherent to implementing technology and what needs to be accomplished to overcome these problems. Vicente (2006) asserted that human factors engineering is the beginning of creating a successful strategy in implementing technology. According to Vicente (2006), human needs and capabilities have to be addressed to determine the “fit” of the technology with the human element.

A pen is a simple device. All seven Arizona CRNA providers in this study had used, or are using, pen and paper for anesthesia documentation. During the cognitive walkthrough, comments about the bulkiness of the pen and concerns about how to carry the pen were voiced. These comments are important in regarding “fit” of the device for the practice setting as well as an area for product improvement.

Staggers’ technology interaction model asserts that not only does the machine have to “fit” the human, but factors such as context of use, work environment, and existing human behaviors and characteristics need to be evaluated. Any technology evaluation needs to be in the form of iterative development and formal scientific research methods (Staggers, 2003). In this study, the DPP system developed by Shareable Ink® had already been designed with input from an anesthesiologist who recognized the unique strains and performance needs of the anesthesia work environment.

These human/computer interaction theoretical models have ties with more complex sociotechnical theories that focus on innate user qualities such as user satisfaction
(Ammenwerth, Iller, & Mahler, 2006), perceived usefulness and perceived ease of use (Davis, 1993). Themes about perceived ease of use and perceived usefulness, as well as reliability and user control, emerged from analysis of the verbal data collected during the cognitive walkthrough.

In addition, comprehensive sociotechnical models have also been developed that include the qualities of the technology, the attributes of the users, the task involved, the complexity of the infrastructure as well as the processes within the user, task, and infrastructure (Dixon, 1999; Goodhue & Thompson, 1995; Ammenwerth et al, 2006). The intention of this feasibility study was to examine all of the entities listed above by use of various data collection methods.

An evaluation tool from the usability engineering arena, the cognitive walkthrough, was used to test how well the technology would mesh with user, task, and environment. This technique helps designers determine how easy or complex it is for users to use a technology to complete a task. The attributes of the CRNA providers were obtained through the use of the precognitive walkthrough survey, an important step in usability evaluation. This survey indicated that the participants were familiar with both computers and anesthesia documentation, but not so familiar with computerized anesthesia documentation. On the user satisfaction survey, after using the DPP system, CRNA providers rated the system as a useful system. However, CRNAs expressed hesitation about the DPP system in their recorded verbal comments made during the cognitive walkthrough.

The cognitive walkthrough was used to conduct the usability evaluation of the DPP system by CRNA anesthesia providers. The CRNAs simulated documentation tasks as if in their work environments. After familiarity with the anesthesia record form was established, time
constraints had a mild effect on user performance. The participants were reticent about putting down the pen when time was called as they were close to completing the record. Other usability studies have been conducted with registered nurses (RNs) using a DPP system in their actual work environments. Dykes et al. (2006) found that the DPP system was not adequate to meet the electronic documentation needs of the nurses in the acute care setting, even though the DPP system was considered by the nurses to be user friendly. However, RNs in Switzerland were more accepting of the device as it met the documentation needs of the nursing staff (Despont-Gros et al., 2005). My current study demonstrated results similar to the results of the Swiss study in that the CRNAs acknowledged the usability of the device but found faults with the system that left them seeking more information.

To evaluate processes within the infrastructure, an evaluation of stakeholder views via an interview was needed to assess acceptability within the infrastructure. Parent organizations and stakeholders may resist the adoption of this technology. The diffusion of innovation theory (Rogers, 1995) suggests that perceived concerns regarding change itself affect the rate of adoption of an innovation. One of Rogers’ (1995) explanations is that the attitudes of particular stakeholders involved in the decision-making process can either halt or accelerate the process of acceptance. Therefore, the attitudes of stakeholders regarding change and technology implementation bear scrutiny and cannot be dismissed. Stakeholders need to be included when considering a change in an organizational process.

Consequently, diffusion of innovation theory was used to evaluate the acceptability of the DPP system by five non-CRNA stakeholders at a community hospital where anesthesia providers currently are without electronic documentation capability. In any organizational system, any
change in an existing work process can impact the workflow of others. This is especially true in a hospital system in which many departments are interconnected to keep the hospital system operational and continue to provide excellent patient care.

**Findings of the Precognitive Walkthrough CRNA Survey**

Unintentionally, with this particular CRNA sample I was able to capture data from two generations of CRNAs: (a) the younger digital natives who have grown up with computers and (b) the older digital immigrants who have had to adapt to computers (Prensky, 2001). This is important because personal experience with computers would seem to be more prevalent with the younger digital native generation and therefore, this generation would be more likely to gravitate to a computerized system. One should keep in mind though, that the average age of a CRNA is predicted to be 48.2 years by 2015 (Merwin, Stern & Jordan, 2006). The computer usage data by this particular sample demonstrated that computers have become ingrained into all of the participants’ personal and work environments, no matter the generation. Logically, AIMS adoption problems would have to stem from somewhere other than feelings of unfamiliarity with computers.

Of note, few of the CRNAs in this study had ever received a formal computer training class. This information suggests that there is a tendency to learn by trial and error. A trial and error method, in general, would not work well in a hospital setting or with complex technology. In fact, not having appropriate training was clearly identified by CRNAs and stakeholders alike as being a problem. This result is consistent with sociotechnical models regarding technology implementation and proper training.
In this study, two of the seven providers had worked at academic hospitals with fully computerized anesthesia documentation capability at some point in their career. This statistic is consistent with the reported 14% implementation rate of computerized anesthesia records within academic medical centers (Epstein, Vigoda & Feinstein, 2007; Egger Halbeis et al., 2008; Anesthesia Business Consultants, 2009; Cozad, 2009).

Not one CRNA reported being computer illiterate, nor did any CRNA characterize themselves as a computer expert, either. Assuming that this small sample is reasonably representative of most CRNAs, anesthesia providers should have extensive familiarity with computers. Why then is there such a low implementation rate of computerized anesthesia record-keeping systems? Both the CRNA participants and the stakeholders voiced concerns regarding electronic anesthesia records including security of information, ease of use/training, maintenance of system, ability to detect and correct errors, and computer downtime. These concerns raised issues that were addressed in the sociotechnical models previously examined about a technology’s fit with the user, task, and environment, and the technology’s perceived ease of use and usefulness.

The last section of the precognitive walkthrough survey was used to determine the participants’ attitudes toward computers. It is logical to think that a poor attitude toward computer systems would equate to non-acceptance of a computerized documentation system. According to the precognitive walkthrough survey, CRNA providers looked favorably upon incorporating computers into the workplace as they decrease the need to perform boring, repetitive tasks. For example, in anesthesia documentation, recording of vital signs could be considered a boring, repetitive task; therefore, automatic recording of vital signs would be welcomed according to survey. Yet, data from the cognitive walkthrough contradicted this
affirmation in that some participants reported that they feared recording of inaccurate data by a computer because it could have legal implications.

Most of the CRNAs thought that computers do contribute to improvements in patient care. A feature of this DPP system as well as most electronic documentation systems is the ability to track quality improvement measures quantitatively. Yet, the fear of spending more time on computers and less time performing patient care may explain the hesitancy by all respondents to rate this as highly important. Indeed, as the CRNAs noted, meaningful use criteria that is being required by the federal government for electronic documentation systems, will enable outside entities to more readily monitor the documentation of care. As a result, documentation will need to be checked for accuracies or else result in possible payment and reimbursement issues for providers.

About half of the CRNAs felt that patient confidentiality was at increased risk with the use of computers. This concern was also noted by some of the hospital stakeholders in their interview responses (Table 6). Security measures to protect patient data are a top priority for developers and purchasers of electronic documentation systems. Because access to information will be electronic, it remains a potential liability. The majority of CRNAs did think that having a computer record capability can offer increased accuracy, legibility, and completeness. However, the caveat as learned from the IT expert at the stakeholder interview is that computer accuracy can only be as good as the information that is entered.

Most CRNAs believed that computers would add to their daily workload. Furthermore, some of the CRNAs did not look forward to implementing an electronic anesthesia record-keeping system for this reason. Some CRNAs felt that the presence of computers for anesthesia
documentation was only somewhat important. These data seem to indicate that providers are not really eager to convert to fully computerized systems. Therefore, a trial evaluation of a digital pen and paper system may in fact be worthwhile at other facilities needing to transition from a traditional pen and paper process to an electronic anesthesia record. Problems do exist with all systems. If a documentation system is deemed capable of fulfilling all necessary functions, it should be up to the users of the system to determine which technology is chosen for adoption. The DPP system in this study has been found to be usable to providers and acceptable to stakeholders.

**Findings Specific to Cognitive Walkthrough**

The DPP system developed by Shareable Ink® was used in this study. The results of the user satisfaction survey were overwhelmingly positive. Only one individual gave predominantly negative ratings. The comments given by the CRNAs during the cognitive walkthrough were, at best, mixed. Several themes emerged from the audio data: ease of use, perceived usefulness, control of data entry, and reliability. All of these concepts need to be discussed when considering the feasibility of using this technology for anesthesia providers. Ease of use was deemed favorable, but the cognitive walkthrough revealed issues about the bulkiness of the pen and about carrying the pen (Appendix E). Similar comments about pen size were reported in previous DPP studies with RNs (Dykes, et al 2006; Despont-Gros et al., 2009; Yen & Gorman, 2005). In addition, one CRNA noted that it may be easy to lose the pen and then pick up the closest pen and start documenting, which also occurred in prior studies (Dykes et al, 2006; Yen & Gorman, 2005).
Perceived usefulness was another area in which the cognitive walkthrough revealed rich data (Appendix E). Perceived usefulness seemed acceptable to most participants initially, but technology-related problems such as low battery or slow download were viewed unfavorably and tempered participants’ perceptions of system usefulness, particularly when they related these kinds of situations to the reliability of their current documentation systems.

Reliability of the DPP was a major concern of the CRNAs. Some of the reliability problems were a function of the laptop computer used to conduct the study as well as my own lack of extensive knowledge with this DPP system. The most frequently voiced concern was related to the quality of the handwriting recognition technology; conversion from script to text was an issue for all participants. Errors in this process forced a participant to go back and make corrections, which ranged from just a few corrections to almost an entire record. This particular DPP software had limited capability due to its designation as a demonstration product. The demonstration product had a limited dictionary that impacted the ability of the handwriting recognition application to “guess” the written word. The frequent errors in text conversion were disappointing to the participants.

On the other hand, the ability to control the entry of data resonated as a positive feature with most of the CRNAs as well as with a few of the stakeholders. Participants voiced concerns regarding a fully computerized system that could record artifact data or inaccurate data—or perhaps fail to record desired data. Legal issues regarding automatic recording of data were the main concern of the CRNAs. Even though research has been mixed about the legal ramifications of automatic data recording (Feldman, 2004; Sanborn, Castro, Kuroda, & Thys, 1996; Huang, 2009), it is still perceived by many CRNAs to be detrimental. After all, health care providers
have been taught that the best legal protection afforded to providers is through their written record, not through values recorded for them by a machine. One CRNA felt that a fully computerized record system would be better at ensuring record completion and accuracy than the DPP system. Conversely, one CRNA experienced, during the cognitive walkthrough, a pen with a low battery that failed to record the pen strokes and thus capture the data electronically. This led the participant to question the system’s reliability.

General comments made by two CRNAs were of particular interest because both had used a fully computerized system. One CRNA was overwhelming negative about the DPP system after working with an anesthesia information management system that had been developed with that CRNA’s input. This particular computerized system was reported by the CRNA to operate almost flawlessly in that particular hospital setting. However, anesthesia providers within the hospital had to undergo extensive training to use the computer system as well as the paper backup system. On the other hand, a second CRNA currently using an anesthesia information management (AIM) system was so disenchanted with the department’s system that the CRNA asked for contact information for the Shareable Ink ® DPP system.

Participants asked many questions about the Shareable Ink ®DPP system during the cognitive walkthrough. Questions concerning cost, durability, and security were the most prevalent. It became evident that as the participants became less aware of using the device and completing the assigned documentation task, they began to consider how the system would work at their facility. This phenomenon suggested that the DPP system was physically and intellectually easy for the CRNA to use. This observation was verified by CRNA responses in
the user satisfaction survey. This result is similar to the studies conducted by Despont-Gros et al. (2009) in Switzerland with RNs in the emergency room environment.

**Findings from the User Satisfaction Survey**

Table 4 shows the preponderance of positive comments about the Shareable Ink® DPP system. All participants rated the DPP system as very easy to learn. The difficulty in correcting typographical errors was reported to be the most negative feature of the system. This DPP system would require providers to improve their handwriting to alleviate errors and the company to build extensive lexicons to improve word recognition.

**Findings from Stakeholder Interviews**

Only two of the stakeholders interviewed had heard of a digital pen and paper system, and none of the stakeholders had used a DPP system. The stakeholders suggested several potential applications of the DPP system: (a) an alternative input device for use by older physicians and older nurses in moving to electronic documentation in all aspects of charting, (b) the ability to pick up and correct errors and omissions on the anesthesia record promptly so as not to delay billing, (c) anesthesia billing submission, and (d) for use in documentation in the operating room, pain management, endoscopy, and PACU. Concerns verbalized about the DPP system included its durability, warranty, charging and the learning curve required to implement.

Overall, stakeholders had relatively few reservations about seeing this system implemented. As a result of these interviews, the group of stakeholders appeared to be eager, early adopters of DPP technology (Rogers, 1995). The stakeholders watched the demonstration, asked thoughtful questions, and concluded that, for a hospital that currently had limited means of computerized documentation, a DPP system may be an option to consider.
Strengths of the Study

The use of several data collection methods helped me to conduct a more complete analysis of the feasibility of the DPP system. The compilation of data from the cognitive walkthrough enabled me to produce evidence that either supported or refuted the comments captured from the user satisfaction survey data. The ability to watch and record the interaction of the participants with the DPP device was much more fruitful than just completing a survey. As the participants “walked through” the motions of using the DPP system, their likes and dislikes were clearly apparent. I am not sure the written word would have captured the personal “meaningfulness” of their experience about the DPP system. Furthermore, the addition of capturing data from other stakeholders in a hospital organization was a new tactic not seen in previous DPP studies. The importance of evaluating technological change by those affected by the technological change is key to technology adoption in an organizational system. In fact, the approval voiced by the other stakeholders was even more compelling when some interviewees revealed that this DPP technology could be useful in more than one department in their hospital organization.

Limitations of the Study

Several limitations to this study need to be addressed. First, the CRNA sample size was sufficient for conducting the cognitive walkthrough, but too small to obtain meaningful quantitative data from the questionnaires. Second, the cognitive walkthrough, even though a good tool, did not enable the participants to perform in an actual work environment. This technique therefore limits the ability to present participants with unique, real-world challenges. Next, my ability to answer questions and educate participants about the Shareable Ink ® product
was limited as compared to the ability of a representative from Shareable Ink®. This particular limitation as well as the system being a demonstration product may have led to unfair criticism of the DPP system. For example, the anesthesia record forms used in the cognitive walkthrough were new to the participants. In the future, using a form from each participant’s facility could decrease problems regarding reliability of documentation that were encountered because of unfamiliarity with a form. Additionally, personal bias for or against the DPP system may have affected answers provided by participants. However, this would be the same as in the real world anesthesia environment. Finally, the stakeholder interviews were undertaken at just one small, community hospital. Input from several facilities of varying size and complexity might have lead to different opinions about the DPP system.

**Implications**

The potential applications of the results of this exploratory study are twofold. First, the results from the user satisfaction survey and the stakeholder interviews could be used by a hospital IT department to warrant an investigation of this product for their hospital’s anesthesia department. This is based on the high marks received from both CRNA participants on the user satisfaction survey and the positive comments given during the interview of other hospital stakeholders. Second, knowing some of the concerns of all the stakeholders, this information could be helpful to the Shareable Ink® Company in improving their product.

**Summary**

The move to electronic health records is in the best interest of the citizens of this country. Some U.S. health care work has converted to computerized systems such as physician ordering and prescription writing. The anesthesia providers in this country not only need to accept this
fact, but also determine the best way to make this transition work for them. No longer is it acceptable to waste thousands of dollars on systems developed by computer engineers and make them fit in the work environment, much like fitting a square peg into a round hole. Proposed technology adoption needs to be a collaborative effort starting with product development, proceeding to testing, implementation and then evaluation of the entire technological change process. Ignoring problems is not acceptable. Either an organization can abandon the idea altogether or correct problems discovered by the stakeholders before full implementation ensues as this is crucial for successful technology adoption.

This study used a DPP system developed with input from an anesthesiologist. The product was tested in this study by CRNAs who came from a variety of backgrounds and experiences. Next, the DPP system was demonstrated to other hospital stakeholders. The stakeholders were queried about the impact of implementing such a system at their small community hospital currently without electronic record capability.

Taken together, the results of this evaluation suggest that the DPP system by Shareable Ink® is a possible device for achieving electronic anesthesia record-keeping. Both CRNA users and hospital stakeholders were satisfied with the product. More important, this study’s evaluation process strengthened the conclusion in that all stakeholders affected were consulted. Strong theoretical frameworks, a variety of data collection tools, and the use of quantitative and qualitative analysis of the data provided the investigator with evidence to support the feasibility of this DPP system for accomplishing electronic anesthesia record-keeping.
APPENDIX A

COMPUTER EXPERIENCE, SKILLS AND ATTITUDES SURVEY
Computer experience, skills and attitudes survey

INSTRUCTIONS:
http://www.surveymonkey.com/s/7QTG8SY;
http://www.surveymonkey.com/s/7QQVCHP;
http://www.surveymonkey.com/s/7QRBDL6

Please circle the most appropriate response to each of the following questions. This is an anonymous survey. The intent is to gain a better understanding of the computer skill sets of CRNA’s and to use this information to determine resource development strategies.

Please be honest with your replies. It is recognized that computer skills vary between individuals.

ABOUT YOU

1. How many hours a week do you work?  <10  10-24  25-40  >40
2. How many years have you been in anesthesia practice?  0-5  6-10  11-15  >15
3. Do you have a computer at home?  Yes □  No □
4. Have you taken a formal computer training course?  Yes □  No □
5. How many hours a week do you use a computer in the following settings?
   At work  0 h  >1 - 5h  6 - 10 h  11-15 h  >15 h
   Home  0 h  >1 - 5 h  6 - 10 h  11-15 h  >15 h
6. Do you use a computerized anesthesia record-keeping system now?  Yes □  No □
7. Have you used a computerized anesthesia record-keeping system?  Yes □  No □
8. Have you used the hospital computer to process a doctor’s order?  Yes □  No □
9. Have you used the hospital computer to look up laboratory test results?  Yes □  No □
10. How do you rate your overall computer literacy?
    Illiterate  1  2  3  4  expert  5
11. What do you think that your current level of computer literacy compared to your desired level of literacy is?

Need more 1 2 3 4 don't need more 5

Access to computers

12. Getting access to a computer at work is:

Impossible 1 2 3 easy 4 5

Rank Your Anticipated Future Need

Please rate your anticipated future needs for the following skills according to their relevance to your professional job effectiveness:

13. How much do you need to upgrade your computer skills in order to perform your job more effectively?

None 1 2 3 significantly 4 5

14. What is the biggest technology-related challenge that you face at work?

Attitude Content

For the following content, please use the key provided below.

Strongly Disagree=1 Disagree=2 Agree=3 Strongly Agree=4 Blank =NA

15. Using computers reduces the need to perform boring, repetitive functions.

1 2 3 4


1 2 3 4
17. Monitoring of care providers by administrators, governmental agencies, and third parties increases when computers are used.

1  2  3  4

18. Patient confidentiality is at increased risk when computers are used.

1  2  3  4

19. Computer use adds to the anesthesia workload.

1  2  3  4

20. I look forward to implementing an electronic anesthesia record-keeping system.

1  2  3  4

For the following questions, please use the key provided below.

<table>
<thead>
<tr>
<th>Very Important=4</th>
<th>Somewhat Important=3</th>
<th>Somewhat Unimportant=2</th>
<th>Very Unimportant=1</th>
<th>Blank=NA</th>
</tr>
</thead>
</table>

21. Computer reports that are more complete, more legible, and offer increased accuracy are:

1  2  3  4

22. Presence of computers for anesthesia documentation are:

1  2  3  4

APPENDIX B
PROCEDURAL GUIDE FOR COGNITIVE WALKTHROUGH METHOD
Information given by Evaluator to participant:

1. Description of the system to participant: Shareable ink details work-flow diagram:

   ![Workflow Diagram]

   a) Components= Electronic Pen and digital dot paper, cradle, internet
   b) Process= Pen assigned in presurgical area, Pen stays with patient, all current documentation is accomplished on same forms that have been printed on dot paper, after patient in PACU pen is downloaded to shareable ink website, data computing accomplished, alert given, onto next patient.
   c) Data that can be tracked, missing data identified, billing data, SCIP data, times plus other dashboards can be defined

2. Description of the tasks as stated by evaluator to the participant:
   Normal perioperative anesthesia documentation tasks participant will be expected to perform:
   1. H&P
   2. Consent
   3. Anesthesia record
   4. PACU, billing forms

3. A script of patient information and vital signs will be provided.

4. List of expected actions and questions that may be asked of the participant by the evaluator:
   a) Assigning pen to patient
      1. What problems do they have using the pen?
      2. What questions did they ask you? What comments or suggestions?
      3. What kinds of situations did they view the pen as being helpful? Not helpful?
b) Power pen on
   1. What problems do they have using the pen?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

c) Perform documentation
   1. What problems do they have using the pen?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

d) Keep pen with patient during handoffs
   1. What problems do they have doing this task?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

e) Place pen in cradle that was installed on designated computer
   1. What problems do they have doing this task?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

f) Download data
   1. What problems do they have using the pen?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

g) Remove pen
   1. What problems do they have using the pen?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

h) Means to contact providers available
   1. What problems do they have doing this task?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

i) Have presurgical unit ready documents for another patient.
   1. What problems doing this task?
   2. What questions did they ask you? What comments or suggestions?
   3. What kinds of situations did they view the pen as being helpful? Not helpful?

j) Have participant envision using DPP system in a different anesthesia work environment.
   1. Name of environment?
   2. What problems doing this task?
   3. What questions did they ask you? What comments or suggestions?
   4. What kinds of situations did they view the pen as being helpful? Not helpful?

Adapted from Wharton, Rieman, Lewis & Polson (1994)
APPENDIX C

MODIFIED QUIS/USER SATISFACTION SURVEY
Modified QUIS/User Satisfaction Survey

http://www.surveymonkey.com/s/7QXKH2Q
http://www.surveymonkey.com/s/7QXRDM5

Please circle the numbers which most appropriately reflect your impressions about using this computer system.
Not Applicable = NA

PART 1: Overall User Reactions

1.1 Overall reactions to the Pen: Terrible Wonderful
1 2 3 4 5 6 7 8 9 NA

1.2 Frustrating Satisfying
1 2 3 4 5 6 7 8 9 NA

1.3 Difficult Easy
1 2 3 4 5 6 7 8 9 NA

Comments:

PART 2: Readability

2.1 Characters on the computer screen were: Hard to read Easy to read
1 2 3 4 5 6 7 8 9 NA

Comments:

PART 3: Learning Features

3.1 Learning to operate the Pen was: Difficult Easy
1 2 3 4 5 6 7 8 9 NA

3.2 Exploration of the features trial and error was: Discouraging Encouraging
1 2 3 4 5 6 7 8 9 NA

3.3 Remembering names and use of commands was: Difficult Easy
1 2 3 4 5 6 7 8 9 NA

3.4 Tasks can be performed in a straight-forward manner: Never Always
1 2 3 4 5 6 7 8 9 NA

Comments:
## PART 4: System Capabilities

4.1 System speed to upload was:  
- Too slow  
  1 2 3 4 5 6 7 8 9 NA  
- Fast enough  

4.1.1 Response time from server:  
- Too slow  
  1 2 3 4 5 6 7 8 9 NA  
- Fast enough  

4.1.2 Rate information download is displayed:  
- Difficult  
  1 2 3 4 5 6 7 8 9 NA  
- Easy  

4.2 The system is reliable:  
- Never  
  1 2 3 4 5 6 7 8 9 NA  
- Always  

4.2.1 The system warns you about potential problems:  
- Never  
  1 2 3 4 5 6 7 8 9 NA  
- Always  

4.3 Correcting your mistakes was:  
- Difficult  
  1 2 3 4 5 6 7 8 9 NA  
- Easy  

4.3.1 Correcting typos was:  
- Complex  
  1 2 3 4 5 6 7 8 9 NA  
- Simple  

4.3.2 Ability to undo operations was:  
- Inadequate  
  1 2 3 4 5 6 7 8 9 NA  
- Adequate  

4.4 Ease of operation depends on your level of expertise:  
- Never  
  1 2 3 4 5 6 7 8 9 NA  
- Always  

Please write your comments about system capabilities here:

APPENDIX D

PROCEDURAL GUIDE AND QUESTIONS FOR STAKEHOLDERS
Procedural Guide and Questions for Stakeholders

1. Job title/unit _______________________________
   Date of evaluation ____________________
2. What are your top three concerns when thinking about implementing an electronic anesthesia record-keeping system?
3. Have you heard or worked with a digital pen product in the past?
4. DEMO the pen

5. What applications do you see for the digital pen system in this hospital?
6. Would you have any concerns about implementing this digital pen system?
APPENDIX E

CRNA COMMENTS DURING COGNITIVE WALKTHROUGH
## CRNA Comments During Cognitive Walkthrough

<table>
<thead>
<tr>
<th>CRNA 1</th>
<th>Perceived Ease of Use</th>
<th>Perceived Usefulness</th>
<th>Reliability</th>
<th>User Control of data entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSITIVE</td>
<td>Not a problem to carry around</td>
<td>POSITIVE</td>
<td>Good to have paper backup if computer fails</td>
<td>POSITIVE</td>
</tr>
<tr>
<td></td>
<td>Writes okay not my favorite but okay for checking boxes</td>
<td>Would work well in a rapid turnover environment</td>
<td>None</td>
<td>POSITIVE</td>
</tr>
<tr>
<td></td>
<td>This is how we currently chart in my practice</td>
<td>No change in work flow</td>
<td>NEGATIVE</td>
<td>None</td>
</tr>
<tr>
<td>NEGATIVE</td>
<td>I drop and lose pens all day</td>
<td>NEGATIVE</td>
<td>It’s not recognizing my handwriting and I have good handwriting</td>
<td>NEGATIVE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRNA 2</th>
<th>Perceived Ease of Use</th>
<th>Perceived Usefulness</th>
<th>Reliability</th>
<th>User Control of data entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSITIVE</td>
<td>Can you use same anesthesia record that I am used to using at the hospital</td>
<td>POSITIVE</td>
<td>Good to have paper backup if computer fails</td>
<td>POSITIVE</td>
</tr>
<tr>
<td></td>
<td>Good for older practitioners due to mental block with computers</td>
<td>Can do billing with this</td>
<td>None</td>
<td>POSITIVE</td>
</tr>
<tr>
<td></td>
<td>Writes good; writes well</td>
<td>Does it integrate with preexisting charts?</td>
<td>NEGATIVE</td>
<td>NEGATIVE</td>
</tr>
<tr>
<td>NEGATIVE</td>
<td>How much training comes with the purchase?</td>
<td>NEGATIVE</td>
<td>It can record all handwriting?</td>
<td>NEGATIVE</td>
</tr>
<tr>
<td></td>
<td>Cap easy to misplace</td>
<td>Hospital computers are usually slow to download—might slow things down</td>
<td>Who will make sure pen is charged for use? With vocera we just pick up a fresh battery</td>
<td>Text could be a liability if information interpreted incorrectly</td>
</tr>
</tbody>
</table>

NONSPECIFIC
Do you have to write with certain pressure?
Does it alarm if malfunction?

POSITIVE
Downloaded fast this time
NEGATIVE
It's not recognizing my handwriting and I have good handwriting
NEGATIVE
Hospital computers are usually slow to download—might slow things down
NEGATIVE
How long does the ink last?
NEGATIVE
Text could be a liability if information interpreted incorrectly
CRNA 3

POSITIVE
Feels like a regular pen
System has to be user friendly

NEGATIVE
We created macros and sequences in a fully computerized system—easier to use than writing
I don’t like the color ink on the paper (red)
Really have to push hard with pen
Difficult to use in expedient cases where our macros make sense, I click one button and everything is populated
I won’t be using it

POSITIVE
Have to have a good tech for our computerized system—this system?

NEGATIVE
Seems like duplication
I am used to a computer
Computer system can only be accessed with usernames and password—increased security
Doctors will never scan records into chart they will have secretary do it

POSITIVE
We train our users how to go to paper backup if our system fails this system is a paperback up

NEGATIVE
Making corrections on the DPP system may not hold up in court
Can’t read my own writing sometimes
If you only fix record on computer and not written one—could have conflict

POSITIVE
None

NEGATIVE
My system automatically records VS and we cannot leave the OR if our record is not complete

CRNA 4

POSITIVE
This is kind of fun—I like this
Writes easy, not too heavy—good size

NEGATIVE
None

NONSPECIFIC
How does it know times?

POSITIVE
This is no different than my paper charting
I am used to pen and paper—so no change for me
Analytics was really neat
So you download pen in PACU if you have time? Would locums just get a pen to take with them?

NEGATIVE
None

POSITIVE
Has a battery indicator light

NEGATIVE
None

POSITIVE
None

NEGATIVE
None

NEGATIVE
None

NEGATIVE
None

NEGATIVE
None
CRNA 5

POSITIVE
I love the technology—great idea
It is large and bulky which is not a problem for me
flow well fine tip
I just put pen in cradle to dock?

NEGATIVE
Not sure how it would stay in my shirt pocket

POSITIVE
I am used to pen and paper—so no change for me
Bluetooth capability?
So this is not an actual computerized record until it is docked?

NEGATIVE
Can you re-assign the pen everyday to more than one person?
Bad handwriting will derail handwriting recognition technology
One pen to one person could be a problem
People will not be likely to fix charts if the charts leave the periop area—
Will it download data as text?
Security could be an issue with any computer system—I am not worried about this—have to figure out

POSITIVE
Has a battery indicator light
NEGATIVE
How long does the ink last?
My penmanship would have to improve
Looks like you still need someone to review the record for accuracy
How durable is it?

NONSPECIFIC
When it docks does it empty the banked data out?

POSITIVE
I don’t like any vital signs charted for me
It only records data I input-SOLD!! I do not like computer telling me patient is in sinus rhythm—when it isn’t—interference recorded a problem—only reason I have been hesitant to accept computerized charting
I don’t want all data recorded like a computer system may do—because artifact and false data doesn’t need to be on a chart—I can choose

NEGATIVE
My penmanship would have to improve
Is it tracking what I am doing?
CRNA 6

POSITIVE
None

NEGATIVE
Too big—I like really small pen

CRNA 7

POSITIVE
Oldest people do not like computers this would be helpful

NEGATIVE
I don’t like any vital signs charted for me

Our current computer system is painful—this was a breeze

It doesn’t require another computer screen—I have 3 computer screens right now

This is better than our system—no way to correct we have to handwrite on bottom of form to explain deficiencies

Seems just like using a regular pen and paper—I am not learning new technology—just need to have my hospital’s own form

Our old paper forms had a wax base on them—had to go get a special Space pen to write

The nurses have to ask 50 questions of
me to document my stuff in the computer like LMA, antibiotics—arghh Locums could come in and use day of work—not our fully computerized system they have to be trained

NEGATIVE Bad handwriting will derail
APPENDIX F

CONSENT FORMS
Project Title: A Feasibility Evaluation of a Digital Pen and Paper System for Accomplishing Electronic Anesthesia Record-keeping

You are being invited to take part in a research study being conducted by The University of Arizona and asked to read this form so that you know about this research study. The information in this form is provided to help you decide whether or not to take part. If you decide to take part in the study, you will be asked to sign this consent form. If you decide you do not want to participate, there will be no penalty to you, and you will not lose any benefit you normally would have.

WHY IS THIS STUDY BEING DONE?
The purpose of this study is to evaluate the feasibility of using a digital pen and paper system for the purpose of documenting perioperative anesthesia care. The first part of the project is to explore the usability and usefulness of a DPP system.

WHY AM I BEING ASKED TO BE IN THIS STUDY?
You are being asked to be in this study because the device is being tested by certified registered nurse anesthetists and stakeholders in the work environment who may be affected by a DPP system.

HOW MANY PEOPLE WILL BE ASKED TO BE IN THIS STUDY?
7-10 people (participants) will be enrolled in the first portion of the study locally, 5 people will be recruited to complete the second portion of the study. Overall, a total of 12-15 participants will be enrolled.

WHAT ARE THE ALTERNATIVES TO BEING IN THIS STUDY?
The alternative is not to participate.

WHAT WILL YOU BE ASKED TO DO IN THIS STUDY?
Cognitive Walkthrough: Your participation in this study will last up to 1.5 hours and includes one visit.

Cognitive Walkthrough
The cognitive walkthrough will last about 90 minutes. During this time you will be asked to complete a pre-trial questionnaire. You then will be given a short (approximately 10 minute) orientation to the digital pen and paper system and cognitive walkthrough. You will then be asked to try using the DPP system for a simulated patient’s anesthesia documentation, while considering how it might work in your own environment. During this time, you will be asked to talk aloud and the researcher will take notes. The session will be audio recorded. You may be removed from the study by the investigator if you are unable to perform the cognitive walkthrough.
WILL VIDEO OR AUDIO RECORDINGS BE MADE OF ME DURING THE STUDY?
Required recordings:
The researcher will make an audio recording during the study to ensure the accuracy of the data used for later analysis. If you do not give permission for the audio recording to be obtained, you cannot participate in this study.

Please initial your decision below.

_______ I give my permission for audio recordings to be made of me during my participation in this research study.

_______ I do not give my permission for audio recordings to be made of me during my participation in this research study.

ARE THERE ANY RISKS TO ME?
Although the researchers have tried to avoid risks, you may feel that some questions/procedures that are asked of you will be stressful or upsetting. You do not have to answer anything you do not want to.

ARE THERE ANY BENEFITS TO ME?
There may be no direct benefit to you by being in this study. What the researchers find out from this study may help other people understand the advantages and disadvantages to the electronic pen and paper system.

WILL THERE BE ANY COSTS TO ME?
Aside from your time, there are no costs for taking part in the study.

WILL I BE PAID TO BE IN THIS STUDY? $10 monetary gift will be given to participants who participate in this evaluation in full.

WILL INFORMATION FROM THIS STUDY BE KEPT CONFIDENTIAL?
Information about you will be stored in a locked file cabinet; computer files will be protected with a password. The consent form will be filed in a secure location at Midwestern University.

Information about you will be kept confidential to the extent permitted or required by law. People who have access to your information include the Principal Investigator and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the University of Arizona Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly. The institution(s) where study procedures are being performed may also see your information. However, any information that is sent to them will be coded with a number so that they cannot tell who you are. Representatives from these entities can see information that has your name on it if they come to the study site to view records. If there are any reports about this study, your name will not be in them.
WHOM CAN I CONTACT FOR MORE INFORMATION?
You can call the Principal Investigator to tell him/her about a concern or complaint about this research study. The Principal Investigator Kathleen A Piotrowski CRNA, can be called at (623) 251-5266. You may also contact the Principal Investigator’s advisor, Judith Effken, PhD at (520) 626-6307.

For questions about your rights as a research subject; or if you have questions, complaints, or concerns about the research and cannot reach the Principal Investigator or want to talk to someone other than the Investigator, you may call the University of Arizona Human Subjects Protection Program office.
- Local phone number: (520) 626-6721
- Website (this can be anonymous: http://orcr.vpr.arizona.edu/irb/contact)

MAY I CHANGE MY MIND ABOUT PARTICIPATING?
You have the choice whether or not to be in this research study. You may decide to not begin or to stop the study at any time. If you choose not to be in this study, there will be no effect on your employment. You can stop being in this study at any time with no effect on your employment.

STATEMENT OF CONSENT
I agree to be in this study and know that I am not giving up any legal rights by signing this form. The procedures, risks, and benefits have been explained to me, and my questions have been answered. I know that new information about this research study will be provided to me as it is available and that the researcher will tell me if I must be removed from the study. I can ask more questions if I want. A copy of this entire, signed consent form will be given to me.

________________________________________  ______________
Subject’s Signature                      Date

________________________________________  ______________
Witness                                     Date

INVESTIGATOR’S AFFIDAVIT:
I have carefully explained to the subject the nature of the above project. I hereby certify that to the best of my knowledge the person who signed this consent form was informed of the nature, demands, benefits, and risks involved in his/her participation.

________________________________________  ______________
Signature of Investigator                  Date
Project Title: A Feasibility Evaluation of a Digital Pen and Paper System for Accomplishing Electronic Anesthesia Record-keeping

You are being invited to take part in a research study being conducted by The University of Arizona and asked to read this form so that you know about this research study. The information in this form is provided to help you decide whether or not to take part. If you decide to take part in the study, you will be asked to sign this consent form. If you decide you do not want to participate, there will be no penalty to you, and you will not lose any benefit you normally would have.

WHY IS THIS STUDY BEING DONE?
The purpose of this study is to evaluate the feasibility of using a digital pen and paper system for the purpose of documenting perioperative anesthesia care. The first part of the project is to explore the usability and usefulness of a DPP system. The second portion of the project is to explore the acceptability of a DPP system to other stakeholders in the work environment who may be affected by a DPP system.

WHY AM I BEING ASKED TO BE IN THIS STUDY?
You are being asked to be in this study because the device is being tested by certified registered nurse anesthetists and stakeholders in the work environment who may be affected by a DPP system.

HOW MANY PEOPLE WILL BE ASKED TO BE IN THIS STUDY?
7-10 people (participants) will be enrolled in the first portion of the study locally, 5 people will be recruited from a hospital without an electronic anesthesia documentation system to complete the second portion of the study. Overall, a total of 12-15 participants will be enrolled.

WHAT ARE THE ALTERNATIVES TO BEING IN THIS STUDY?
The alternative is not to participate.

WHAT WILL YOU BE ASKED TO DO IN THIS STUDY?
Stakeholder Interviews: Your participation in this project should not last more than 45 minutes. The procedures you will be asked to perform for each activity are described below.

Stakeholder Interview
If you agree to participate, I will schedule a time in which I can interview you. The interview will last about 45 minutes and will include questions about the potential advantages or disadvantages of the digital pen system within your institution, from your point of view. Prior to the interview, you will be shown the digital pen system and its use explained.
WILL VIDEO OR AUDIO RECORDINGS BE MADE OF ME DURING THE STUDY?
Required recordings:
The researcher will make an audio recording during the study to ensure the accuracy of the data used for later analysis. If you do not give permission for the audio recording to be obtained, you cannot participate in this study.

Please initial your decision below.

________ I give my permission for audio recordings to be made of me during my participation in this research study.

________ I do not give my permission for audio recordings to be made of me during my participation in this research study.

ARE THERE ANY RISKS TO ME?
Although the researchers have tried to avoid risks, you may feel that some questions/procedures that are asked of you will be stressful or upsetting. You do not have to answer anything you do not want to.

ARE THERE ANY BENEFITS TO ME?
There may be no direct benefit to you by being in this study. What the researchers find out from this study may help other people understand the advantages and disadvantages to the electronic pen and paper system.

WILL THERE BE ANY COSTS TO ME?
Aside from your time, there are no costs for taking part in the study.

WILL I BE PAID TO BE IN THIS STUDY? $10 monetary gift will be given to participants who complete this evaluation.

WILL INFORMATION FROM THIS STUDY BE KEPT CONFIDENTIAL?
Information about you will be stored in a locked file cabinet; computer files will be protected with a password. The consent form will be filed in a secure location at Midwestern University.

Information about you will be kept confidential to the extent permitted or required by law. People who have access to your information include the Principal Investigator and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the University of Arizona Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly. The institution(s) where study procedures are being performed may also see your information. However, any information that is sent to them will be coded with a number so that they cannot tell who you are. Representatives from these entities can see information that has your name on it if they come to the study site to view records. If there are any reports about this study, your name will not be in them.
WHOM CAN I CONTACT FOR MORE INFORMATION?
You can call the Principal Investigator to tell him/her about a concern or complaint about this research study. The Principal Investigator Kathleen A Piotrowski CRNA, can be called at (623) 251-5266. You may also contact the Principal Investigator’s advisor, Judith Effken, PhD at (520) 626-6307.

For questions about your rights as a research subject; or if you have questions, complaints, or concerns about the research and cannot reach the Principal Investigator or want to talk to someone other than the Investigator, you may call the University of Arizona Human Subjects Protection Program office.
- Local phone number: (520) 626-6721
- Website (this can be anonymous: http://orcr.vpr.arizona.edu/irb/contact)

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I agree to be in this study and know that I am not giving up any legal rights by signing this form. The procedures, risks, and benefits have been explained to me, and my questions have been answered. I know that new information about this research study will be provided to me as it is available and that the researcher will tell me if I must be removed from the study. I can ask more questions if I want. A copy of this entire, signed consent form will be given to me.

__________________________________________
Subject's Signature

__________________________________________
Date

__________________________________________
Witness

__________________________________________
Date

INVESTIGATOR'S AFFIDAVIT:
I have carefully explained to the subject the nature of the above project. I hereby certify that to the best of my knowledge the person who signed this consent form was informed of the nature, demands, benefits, and risks involved in his/her participation.

__________________________________________
Signature of Investigator

__________________________________________
Date
APPENDIX G

IRB DOCUMENTS
IRB Documents

**HSPP Correspondence Form**

**Date:** 12/16/10  
**Investigator:** Kathleen Pietrokovski, Doctoral Student  
**Advisor:** Judith Ehlen, PhD  
**Department:** Nursing  
**Project No./Title:** 10-0920-00 A Feasibility Evaluation of a Digital Pen & Paper System for Accomplishing Electronic Anesthesia Record-Keeping  
**Current Period of Approval:** 12/16/10 – no expiration

<table>
<thead>
<tr>
<th>Administrative Action</th>
<th>Documents Reviewed Concurrently</th>
<th>Status</th>
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<tbody>
<tr>
<td>F200: Approval for Human Research</td>
<td></td>
<td>Appr</td>
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<tr>
<td>Consent Instruments: Consent</td>
<td></td>
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<tr>
<td>Stakeholder interview consent</td>
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<td>F107: Verification of Training Form</td>
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<td>Recruitment Materials: Script (part 1 and 2), follow-up phone recruitment part 2</td>
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<td>Site Authorization: Email from Ron Russ, Draft site authorization letters</td>
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<td>Appr</td>
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<tr>
<td>Other: CV - PI</td>
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<tr>
<td>Data Collection Instruments: Computer experience, skills and attitudes</td>
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<td>Investigator's Procedural Guide</td>
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<td>Modified QUIS</td>
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<tr>
<td>Interviewer procedure guide</td>
<td></td>
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</table>

**Determination**

**Requirements**

- **Research Site Authorization Requirement:** Clearance from official authorities for sites where research is to be conducted must be obtained prior to performance of this study at those sites. Evidence of this must be submitted to the HSPP office.

- **Regulatory Determination(s)**

  - **Exempt Approval 45 CFR 46.101(b)(2):** Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior.

**IRB Committee Information**

**Administrative Review – New Submission**

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**Sheryl Warl, PhD**  
Director, Human Subjects Protection Program  
UA Institutional Review Board

12/16/10
January 24, 2011

Kathleen Piotrowski
15722 W. Cortez St.
Surprise, AZ 85379


Dear Ms. Piotrowski,

Thank you for submitting this project to the IRB. After review it appears that this project does not meet the definition of human subject research. Human subject means a living individual about whom an investigator (whether professional or student) conducting research obtains: (1) Data through intervention or interaction with the individual, or (2) Identifiable private information. The purpose of this project is to evaluate the feasibility of a digital pen and paper system for accomplishing the implementation of electronic anesthesia documentation. Therefore while you are interacting with human subjects you are not collecting information about the individual, you are collecting information about the use of the digital pen and paper system for documentation purposes.

This project does not need to be reviewed by the IRB.

If you have any concerns or questions please contact the IRB at irb@summahealth.org

Thank you,

Jessica Conrad, MS, CIP
Human Subjects Protection Program Manager
REFERENCES


Webster, C., Stabile, M., & Merry, A. F. (2009). The challenges of technological intensification. APSF newsletter, 24(3), 33, 35 & 43. APSF.

