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Nurses As Knowledge Work Agents: Measuring The Impact Of A Clinical Decision Support System On Nurses' Perceptions Of Their Practice And The Work Environment

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Abstract
Background: The HITECH act's financial incentives and meaningful use mandates have resulted in unprecedented rates of EHR and CDSS adoption. These systems are premised on evidenced-based guidelines, the standardization of care, and the reduction of subjective clinical decisions. They are designed to record clinical events, synchronize the efforts of care teams, facilitate the exchange of information, and improve the control and design of clinical processes. Knowledge workers are challenged to assimilate these changes into a deliberative and autonomous style of practice.

Aims: The study examined the impact of a CDSS implementation on nurses' perceptions of their ability to perform aspects of knowledge work and on the nursing practice environment. Nurse and clinical unit characteristics were examined to identify those that predicted outcome variance.

Methods: This study used The Impact of Health Information Technology (I-HIT) and The Essentials of Magnetism II (EOM II) instruments. Guided by the Quality Health Outcomes Model, this pre-post, quasi-experimental study includes t-tests, repeated measure and univariate general linear model regression analyses. Two groups comprised the convenience sample of 1,045 nurses: a paired (n=458) and independent (n=587).

Results: The functionality of the CDSS was perceived to reduce nurses' ability to efficiently practice, communicate, share information, and interfered with workflow in ways that depersonalized care. Perceptions of the practice environment, interestingly, remained essentially unchanged, with slight improvements and no statistically significant declines. This included perceptions about autonomy, patient-centered values, professional satisfaction and quality care. Even though the CDSS's functionality interfered with practice, and may be poised to deemphasize subjective judgment and autonomy, nurses did not seem to reject the CDSS's ability to standardize aspects of care. This study also found that nurse and clinical unit characteristics such as clinical unit type, shift, expertise, race, and whether or not nurse education was obtained outside of the USA, explained more variance than years of experience, institutional tenure, and level of education.

Conclusion: Results suggest that nursing science needs to investigate and advise the design of CDSSs, as well as, develop tactics to reap the benefits of processes and guidelines, while preserving knowledge works' emphasis on expertise, intuition, and holistic care.

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NURSES AS KNOWLEDGE WORK AGENTS:

MEASURING THE IMPACT OF A CLINICAL DECISION SUPPORT SYSTEM ON NURSES' PERCEPTIONS OF THEIR PRACTICE AND THE WORK ENVIRONMENT

Sandra Gayle Jost

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This work is dedicated to:

Bill

&

Robert and Kathleen

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ABSTRACT

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Background and Significance

Healthcare institutions are hindered by thin margins and restrictive capital budgets, and tend to shy away from expenditures that cannot be associated with known returns on investment and proven streams of revenue (Chaiken, 2003; Japsen, 2011). Clinical Decision Support Systems (CDSSs), which represent major capital outlays have, consequently, found implementation at less than two percent of hospitals (DesRoches et al., 2010; Jha, DesRoches, & Rosenbaum, 2009; Jha, DesRoches, Kralovec, & Joshi, 2010).

Three major incentives are converging, however, to compel unprecedented rates of CDSS adoption: 1) The Health Information Technology for Economic and Clinical Health Act (HITECH), designed to modernize healthcare's information systems, and move it across the digital divide, contains tens of billions of dollars in incentives, penalties and deadlines, and forces healthcare systems to comply with minimal standards of meaningful use (Blumenthal, 2011; Mcbride, Delaney, & Tietze, 2012); 2) Healthcare administrators are besieged with complexity (Plsek & Wilson, 2001; Porter-O'Grady & Malloch, 2007; Porter-O'Grady & Malloch, 2009), including the threat of liability; increased regulatory scrutiny (Institute of Medicine, 2012); pay for performance (Kruse, Polsky, Stuart, & Werner, 2012); and the impact of healthcare reform (Chaudhry et al., 2006). They are, as such, motivated to implement CDSSs to impose best practice assessments at the point-of-care, with the objective of streamlining clinical interactions, and eliminating variability and errors (Garg et al., 2005; Goth, 2009); and 3) The processing power and software necessary to accommodate the clinical setting is now quite mature. Modern CDSSs are engineered as modules that compliment comprehensive suites of software, designed to coordinate patient care, drug delivery, and order entry (Berner, 2016; Osheroff et al., 2006).

Nurses are positioned to be disproportionately impacted by increasing numbers of CDSSs in the clinical setting (Kutney-Lee & Kelly, 2011). Nurses comprise healthcare's largest clinical workforce: 2.9 million (Bureau of Labor Statistics, U.S. Department of Labor, 2010-2011; Robert Wood Johnson (RWJ)/ Institute of Medicine (IOM), 2010), and it is nurses who spend the majority of time at the bedside, charged with performing and documenting assessments, interventions, and therapy (Kim, Dykes, Thomas, Winfield, & Rocha, 2011). The CDSSs that nurses will encounter are not passive standalone systems, or simply databases of translated paper documents and electronic medical histories. Modern CDSSs analyze information from nearly all aspects of clinical workflow (McGonigle & Mastrian, 2012). They are designed to assess patient status, and push recommended interventions and order entry steps—derived from databases of evidence based practice—to the bedside nurse (Bakken et al., 2008; Berner, 2016; Bowles, 2004).

The modern CDSS is also designed and integrated into the workflow to provide an intuitive and immersive experience. This is more possible than it ever has been, because CDSSs have benefited from a cultural and technological shift, derived from ubiquitous mobile devices. CDSSs have, in other words, found a conduit to more seamlessly collect data from nurses, as well as extemporaneously inform and advise them. Until just a few years ago it would have seemed unnatural, even disruptive to expect that nurses would pay attention to a mobile device during the performance of their activities. Yet, devices such as the iPad and smart phone have captured the spirit of the age, and are able to render attractive, friendly, and familiar interfaces. Consider that nurses interact with smart phones as they wait in line for coffee, use iPads as they relax in cafés, and that such devices are used routinely to narrate and broadcast mundane experiences as they occur. Nurses, similar to the rest of society, have become accustomed to using their tablets and smart phones as ready repositories of knowledge.

It is essential, in light of these technological, legislative, and cultural trends, that nursing study the relationship between practice and the imminent widespread deployment of CDSSs. This

dissertation aspired to answer this need and was the first to examine the influence of a CDSS, on perceptions that nurses have about their practice and work environment.

This dissertation was also innovative because it marked a first step towards establishing a program of research, designed to study nursing knowledge work. Nursing knowledge work acknowledges that clinical environments have become exceptionally complex, and dependent on the use and the availability of information and knowledge. It also acknowledges that, in response to this imperative, nursing "work" will deemphasize aspects that can be defined explicitly and executed by paraprofessionals—and more concerned with using knowledge to attenuate clinical complexity.

While nursing knowledge work has increasingly been used to express knowledge as central to practice, the concept lacks a guiding theory and body of research. My research aspiration is to address this deficit. Specifically, to explicate the means by which institutional and individual characteristics—believed associated with the deployment of knowledge—may be effectively and reliably matched. The implementation of a CDSS at a major academic research center was an opportune venue to initiate this work. This is because CDSSs are believed to enhance many of the attributes that facilitate nursing knowledge work. This pre and post survey looked for relationships between the CDSS, and elements of practice that rely on professional deliberation, communication, and autonomy.

Nurse knowledge workers inhabit complex healthcare systems, and in an aggregate sense, can be conceptualized as a reservoir of deliberative thought (Jost, 2012). This reservoir of deliberation is deployed in unpredictable ways, and at unpredictable times. For example, to anticipate and resolve problems, settle emergent indeterminacies, deal with competing and conflicting demands (Porter-O'Grady, 2003), and to discern salient patterns and subtle clues—often on the basis of only scant evidence (Gigerenzer, Todd, & ABC Research Group, 1999; Klein, 1999; Klein, 2009; Kosko, 2006).

The capacity to perform knowledge work is dependent on intelligence, education, pattern recognition, and a tacit understanding of evidence-based best practice procedures (Jost, 2012). The most important determinants of nursing knowledge work, however, are derived from the experience, expertise, and the confidence that accrues from autonomous and deliberative practice (Antrobus, 1997; Benner & Tanner, 1987; Benner, 1984).

Statement of the Problem

There is an urgent need to learn, before CDSSs proliferate, what the impact of this technology will have on nursing knowledge work. The first steps should seek to understand if CDSSs generally promote environments of nurse empowerment and autonomy, or if they encourage reflexive compliance.

CDSS vendors emphasize the ability to deliver evidence based practice protocols and standards (Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000) in a timely and contextually appropriate way (Chaudhry, 2008; Harrington, Kennerly, & Johnson, 2011; Lee, 2014). It is critical that nursing study the impact that this will have on nurses, and on the development of nurse knowledge workers. Nurses may become accustomed to responding to the CDSS's recommendations in an algorithmic fashion, absent deliberation and professional self-reflection. That is, without the stream of consciousness that nurse knowledge workers engage in—thinking about the efficacy of their clinical thinking and interventions—even as they are engaged in the midst of practice (Johns, 1999). Should CDSSs promote reliance, it may serve to preempt professional maturation, and it may leave the complex system of healthcare less provisioned to respond to atypical scenarios. These atypical situations are emergent and unpredictable, and defy clear standards and protocols, to which knowledge workers respond.

Alternatively, nursing needs to understand how CDSSs may complement nurse expertise in unexpected ways. They may enhance productivity, and may work in a dialectical fashion

(Benner, Tanner, & Chesla, 1997) to allow nurses to attain expertise more quickly and fully. CDSSs may also facilitate the right information at the right time to allow nurses to improvise (Quinlan, 2009; Thomas, Bostrom, & Gouge, 2007), and resolve complex problems with great efficacy.

Existing studies that address the impact of CDSSs on the clinical setting are of limited value with respect to nursing knowledge work. The majority of these tend to focus on provider acceptance (Ammenwerth, Iller, & Mahler, 2006; El-Kareh et al., 2009; Im & Chee, 2006; Sockolow, Lehmann, & Weiner, 2009; Sockolow, Weiner, Bowles, Abbott, & Lehmann, 2011), neglect the influence of CDSSs on workflow and patient outcomes (Randell & Dowding, 2010; Shojania et al., 2009), underemphasize bedside nursing generally, and spotlight select diagnosis and specific care delivery environments (Cleveringa, Gorter, & Rutten, 2008; Ludwick & Doucette, 2009; Lyerla, LeRouge, Cooke, Turpin, & Wilson, 2010; Tierney et al., 2005).

Specific Aims

This dissertation sought to leverage a natural experimental condition, where the study site chose to implement a CDSS. This implementation of a CDSS was an expansion of the previously implemented electronic medical record comprised of a fully integrated computerized provider order entry (CPOE), electronic medication administration record (eMAR), lab, and radiology. The study site had been fully functional on these technologies since 1996. The addition of the CDSS component to the well-established suite of electronic solutions at this site was of interest because it introduced evidence-based order sets and over 200 clinical practice guidelines, along with their associated standardized documentation templates. The implementation of this system's type of broad clinical decision support of the entire interdisciplinary team represented an important first step in moving CDSS functionality away from narrowly defined, disease-specific, physician-focused systems that have been the primary focus of research (Garg et al., 2005;

Jemielniak, 2009). This type of system is intended to support practice through integration of the most current research evidence with the clinical expertise of the entire care delivery team (Bergstrand, 2009; Berner, 2016; Straus, 2005).

This dissertation measured direct care nurses' perceptions of their knowledge work, prior and subsequent to implementation of a CDSS integration into the existing EHR. The instruments utilized for measurement, the Impact of Health Information Technology Scale©(I-HIT) (Dykes, Hurley, Cashen, Bakken, & Duffy, 2007; Weaver, 2006) and the Essentials of Magnetism II© (EOM II) (Schmalenberg & Kramer, 2008), were selected because they inquire about attributes of autonomous decision-making, communication, and collaboration associated with nursing knowledge work. Such attributes include the ability to self-organize; synthesize information; evaluate novel solutions; reconcile multiple and simultaneous demands; deal with indeterminacies; and continually reassess and reprioritize. This study also measured nurses' perceptions of the larger clinical environment pre and post system implementation. This includes nurses' perceptions of peer competency; the nature of nurse-physician interactions; and the impact on patient-centered culture.

The CDSS is innovative because of its integration into the minute-to-minute workflow (assessment, decision-making, and intervention) and practice environment (coordination and communication of care with the interdisciplinary team and family). It also extends more "traditional" narrowly-defined rule and reminder CDS functionality by providing a singular electronic space for all care providers to enter, view, analyze, and synthesize patient data--creating transparency across care provider disciplines (Yan, 2005). In this CDSS, physicians, nurses, therapists, and social workers have access to view one another's assessments and interventions supporting a virtual workspace for collaboration (Penn Medicine, 2012). Accordingly, the specific aims of this study were to:

Aim 1: Examine the impact of a CDSS implementation on nurses' perceptions of their ability to perform aspects of knowledge work and on the nursing practice environment.

H_0: There will be no change in the nurses' perceptions of their ability to perform aspects of knowledge work or their nursing practice environment, measured by the I-HIT and EOM II respectively, from baseline (pre-implementation) to eight months post-implementation.

Aim 2: Examine a set of nurse and patient care unit characteristic variables and the corresponding explained variance associated with nurses' perceptions of their ability to perform aspects of knowledge work and the nursing practice environment (measured by each I-HIT and EOM II subscale).

CHAPTER 2: REVIEW OF THE LITERATURE

Healthcare System Complexity

Today's healthcare delivery system is undergoing a radical transformation. The Patient Protection and Affordable Care Act (PPACA), commonly called Obamacare, extended healthcare to approximately 32 million nonelderly, uninsured, and underinsured citizens (Wilensky, 2012). These demands combined with those of an aging society, an obesity epidemic, a trend toward patient consumerism, nursing shortages (Needleman, Buerhaus, Stewart, Zelevinsky, & Mattke, 2006; Unruh & Fottler, 2005; The forum of state nursing state workforce center.), and a desire for state-of-the-art services will compound the challenges of healthcare delivery. Healthcare administrators are highly motivated to reign in this complexity, and are naturally attracted to technologies that promise to streamline redundancies, and promote efficacy.

Health information technologies, inclusive of CDSSs, are considered by health care experts, policymakers, payers, and consumers critical to lowering the cost (Bright et al., 2012; Hillestad et al., 2005) and increasing the efficiency of healthcare (Chaudhry et al., 2006; Chaudhry, 2008; Hillestad et al., 2005). The American Recovery and Reinvestment Act (AARA) was passed in response to these concerns. ARRA included 19.2 billion dollars allocated to the Health Information Technology for Economic and Clinical Health act (HITECH). HITECH also specifies "meaningful use" of interoperable EHR adoption in the health care system. Coordination of care is one of five categories specified as meaningful use. Considering the forces impelling the industry toward EHR implementation, it is alarming how little is known about information system effectiveness in supporting nurses to contend with the multiple factors associated with the delivery of care.

Knowledge Work

Knowledge Work: Concept Introduction and Evolution

Peter Drucker, renowned expert in the field of business management, introduced the concept of knowledge work in his book *Landmarks of Tomorrow* (1959). He was impressed by an emergent class of educated and self-directed workers concerned with the pursuit and application of knowledge. Princeton economist Fritz Machlup, at about the same time, published *The Production and Distribution of Knowledge in the United States* (1962). In it, Machlup predicted the *knowledge industry* and differentiated *brain work* from manual labor. His book represented a serious and seminal attempt to understand knowledge as a commodity, and to measure the production and application of knowledge in terms of economic statistics, and percentage of gross domestic product (Davenport, 2005; Wallace, 2007).

In the decades since the introduction of the term, Drucker published prolifically. He explained that instant communications, the World Wide Web, and increases in the availability of information, devalued the previously dominant economic determinants: land, natural resources, and capital (Drucker, 2001; Drucker, 2002). He promulgated knowledge work as an engine of societal progress, poised to untangle some of humanities' most enduring and perplexing problems. He asserted that this realization depended on empowering knowledge workers to explore innovation in volitional fashion. Best-selling futurists and popular management gurus would similarly espouse Drucker's optimism and endorse his admonitions (Bell, 1976; Toffler, 1981).

Drucker, near the end-of-life, conceded that even after four decades, little was known about how to increase the productivity of knowledge work. He considered the resolution of this problem to be management's next frontier (Davenport, 2005; Davenport, 2011; Drucker, 2004). The difficulty stems from the fact that knowledge work resists measures of input and output. No

one can predict which exertions might result in new knowledge, or reliably predict when—and under what circumstances—existing knowledge might be deployed.

The academic literature has primarily focused on frameworks designed to refine the concept, and with theories related to the effective promotion of knowledge work. For example, knowledge worker-management control theory (R. Mitchell & Meacheam, 2011), frameworks for understanding knowledge worker fulfillment (Moon, 2009; Tampoe, 1993), work environment models supportive of efficient information access (Davenport, 2011), knowledge work team interaction (Beyerlein, Johnson, & Beyerlein, 1995), and rapid information exchange (Holtshouse, 2009a; Holtshouse, 2009b; Matson & Prusak, 2010; Tampoe, 1993). Frenkel, Korczynski, Donoghue, and Shire (1995) proposed a three-dimensional framework to define knowledge work as requiring: a) a high level of creativity, b) extensive use of intellective skills, and c) a theoretical rather than a contextual knowledge base. Davenport (2005) advanced a framework to identify knowledge intensive work on the basis of autonomy, training, interaction, routine, and professional judgment.

Knowledge Work: The Popular Usage

Knowledge work, in the years since its introduction, became a fixture of managerial discourse. Employees were extolled, by virtue of the knowledge they possessed and applied, as the most valuable business resource. They were also considered the sole means by which to establish and maintain competitive differentials (Drucker, 1992; Stewart, 1995a; Stewart, 1995b).

Knowledge work was used often to mollify and frame apprehensions about globalism and outsourcing (Crawford, 2009; Drucker, 1998; Garson, 1988; Reich, 2005; Sennett, 2008; Toffler, 1981; Toffler, 1990). It provided context to discussions about job losses in steel, rubber, auto, and other heavy manufacturing industries. In this context, knowledge work was juxtaposed against terms such as *smokestack industry,* and underscored the susceptibility of industrial jobs to

implementation of information systems and programmable automation (Bloch, Frosch, & National Academy of Engineering, 1985; Cornish, 1985).

In addition to explaining job losses, knowledge work was used to encourage displaced workers to participate in occupational retraining programs (Ravnik, 1984). It became synonymous with the *jobs of tomorrow*, and conflated with terms such as *information revolution* and *computer literacy* (Bell, 1976). The potency of this affiliation waned as computers became increasingly ubiquitous and intuitive.

Knowledge work is commonly used to delineate intellectually demanding jobs from those regarded as physical, prescriptive, and repetitive (Adhikari & Sales, 2001; Brint, 2001; Fuller, 2001; Smith, 1977). In this sense, it furnishes part of a popular occupational vocabulary offering easy but meaningful distinctions between work of the body and work of the brain (Rose, 2004). The strength of this distinction helps to explain why so many service sector jobs are mischaracterized as knowledge work, despite that many of them are highly scripted and absent the need for meaningful deliberation and creativity (Crawford, 2009; Ehrenreich, 2011; Garson, 1988; Sennett, 2008).

Knowledge Work: Reducing the Complexity of Systems

Reducing ambiguity, redundancies, and other inefficiencies is fundamental to the modern economy (Costa, 2010; Tainter, 1988). This is explained by the fact that society has, by virtue of accrued understandings and technology, pushed through a number of rate limiting factors, and is now precariously dependent on myriad and interdependent systems (Malthus & Gilbert, 1999). Over 99% of humanity, for example, depends on agriculture, which in turn depends on infrastructures of energy, transportation, refrigeration, engineering, manufacturing, and irrigation (Sagan, 1977). The demands on a complex system are not static. They are continuously taxed by society's appetite for new technology and innovation. This results in new and more formidable

variables which quickly exhaust the state-of-the-art (Garreau, 2005; Gates, Myhrvold, & Rinearson, 1996; Kaku, 1997; Kauffman, 1995; Kurzweil, 2005; Sagan, 1977; Tainter, 1988; Wilson, 2002). Knowledge workers are, as such, charged with simplifying complex systems, rendering them more efficient, and less vulnerable to unforeseen contingencies and disruptions (Bar-Yam, Ramalingam, Burlingame, & Ogata, 2004). Whitehead observed that, "Civilization advances only by extending the number of important operations that can be performed without thinking about them" (1958, p. 61). Paradoxically, this involves, using extraordinary human ingenuity to eliminate the need for human ingenuity (Garson, 1988). Knowledge work is concerned, then, with finding complex work amenable to reengineering. That is, breaking the work of experts into discrete steps, and distributing them to coordinated arrays of paraprofessionals, clerks, and technology (Crawford, 2009; Ehrenreich, 2011; Garson, 1988). This trend is reflected in the nursing domain by increased numbers of Licensed Practical Nurses, Certified Nursing Assistants, and technologists (Florida, 2004; Glaeser, 2011; Harper, 1987).

Knowledge Work and Nursing

Drucker referred to nurses as knowledge workers, citing the deliberative nature of their work, and the complex and demanding environment in which they practiced. In the 1980s, Benner researched clinical decision-making and skills acquisition. Her work, along with that of other researchers, explored the role of tacit knowledge, which is internal to the practitioner, and explicit knowledge which could be formally articulated and precisely executed (Benner, 1984; Klein, 1996; Klein, 1997; Klein, 2008; Klein, 2009). Benner explicated the concept of *Intuitive Grasp,* which describes the ability of expert practitioners to fluidly render time sensitive decisions on the basis of incomplete evidence. It also accounts for the ability of seasoned workers to recognize subtle, but critical cues on the basis of scant evidence (Quirk, 2006). Expert nurses were explained by other researchers to evaluate, anticipate, intervene, and scrutinize aspects of

their own practice; to leverage what they have seen before; and imagine forward into a patient's indeterminate future (Klein, 1997; Klein, 2009; Schon, 1983; Sennett, 2008). In the clinical setting, knowledge work involves nurses discerning salient patterns from myriad sources of information.

Benner's *From Novice to Expert* (1984) marked an important and influential work, but the emphasis on intuition—given the predominant gender of nursing—left it susceptible to charges of "irrational guessing" (Correnti, 1992; Gigerenzer, 2000; Gigerenzer, 2002; Gigerenzer, 2007). Researchers were compelled, consequently, to emphasize the expert's reliance on professional knowledge, judgment, and clinical reasoning (Andrews, 1996; Benner & Tanner, 1987; Benner, 1984; Bonis, 2009; Lynn & McConkey, 1998; Simmons, 2010). Benner too would subsequently conjecture that intuitive grasp might stem from rational but unconscious processes that "…develop when the clinician tests and refines propositions and principles based on expectations in actual practice situations" (Benner & Tanner, 1987; Benner, 1984; Rolfe, 1996, p. 52).

Studies aimed at demystifying professional judgment have become increasingly common. Pilots, chess grandmasters, nurses, paramedics, firefighters and other professionals have been subjects of research to explain the root of expertness (Benner, 1984; Dismukes, Berman, & Loukopoulos, 2007; Dreyfus & Dreyfus, 2011; Klein, 1997; Klein, 2008). Some scientists theorize that intuition and professional insight represent non-computational rationality. The assertion follows: "…that true intelligence cannot be attained–or even adequately simulated–strictly by computational means" (Penrose, 1994, p. vi). Others argue that intuition is the result of algorithmic processes that will, eventually, be emulated by artificial intelligence (Hofstadter, 2007). There is, however, some agreement that the set of abilities ascribed to professional intuition derive from three complementary cognitive processes: bounded rationality, heuristics,

and pattern recognition. All of these processes rely on substantial appropriations of knowledge acquired from formal education, informal training, and experience in practice (Antrobus, 1997).

Nursing literature has used knowledge work in ways that tend toward the casual and the imprecise; often knowledge work is used reflexively as an affirmation of nursing professionalism (Brennan & Crawford, 2009; Cody, 2001; Grinspun, 2009; Kim, 2000; Pesut, 2000). In the late 1990s, it was advanced that knowledge work should, more appropriately, be thought of as an attribute of advanced practice and senior nurses (Sorrells-Jones, 1999). It was argued that health care organizations were transforming into knowledge intensive organizations, and that nurses would contribute essential and sophisticated skills to interdisciplinary teams (Sorrells-Jones & Weaver, 1999a; Sorrells-Jones & Weaver, 1999b; Weaver & Sorrells-Jones, 1999).

The nursing literature increasingly acknowledges the complexity of healthcare systems. It asserts that nursing derives its professional value less from the performance of explicit tasks, and more from the ability to gather, synthesize, coordinate, and communicate information essential to critical operations. Snyder-Halpern, Corcoran-Perry, and Narayan (2001) delineated four roles nurses fulfill in knowledge-intensive work environments: data-gatherer, information-user, knowledge-user, and knowledge-builder. This work implored nursing administrators to understand, and prepare the practice environment for the increasingly complex demands nursing would fulfill (Sorrells-Jones, 1999).

The recent Robert Wood Johnson/Institute of Medicine (RWJ/IOM) report: "The Future of Nursing" featured a number of assertive themes that exemplify nursing's use of knowledge. These advocated full partnership with physicians and other health professionals in redesigning aspects of care; educational infrastructures in support of seamless development; and hospital information systems commensurate with informed practice (Robert Wood Johnson (RWJ)/ Institute of Medicine (IOM), 2010). This trend is also marked by the proliferation of evidence-based practice (EBP) (Sackett et al., 2000) which depends on the integration of clinical expertise

and deliberation with patient values, and rejects "direct and control" management models that stifle.

Conceptual Definition

The inductive analysis conducted for this study resulted in the following conceptual definition. The concept of knowledge work can be defined as a cultural response to complexity that occurs when a civilization's systems and processes become ubiquitously interdependent, and derivative of sophisticated principles and theory. The nature of work, under these circumstances, outstrips informal modes of cognition, for example, intuition, mechanical aptitude, trial and error, chance discovery, common sense, and even cultural adaptations such as the apprenticeship model—designed to facilitate the transfer of vocational knowledge. In order to maintain, improve, and understand the systems on which it relies, society must recruit, educate, and train a class of experts able to master and deploy the attributes of knowledge work. These include: tacit knowledge, heuristics, bounded rationality, pattern recognition, and meta-cognition (Jost, 2012).

Attributes

Tacit knowledge. Tacit knowledge refers to the internalization of explicit knowledge in ways that defy articulation. A person, for example, may be quite adept at riding a bicycle, but unable to express the physics and mathematics that govern the action. In the context of knowledge work, tacit knowledge describes the synthesis of formal rules and experiential understandings, often regarded as professional intuition (Nonaka, 1991; Polanyi, 1967). Nurses in neonatal intensive care units, for example, have demonstrated an ability to detect sepsis in babies before lab results confirm the presence of infection. When questioned, these nurses could explain their predictive ability only as a product of "experience" (Crandall & Getchell-Reiter, 1993; Klein, 1999).

Heuristics or rules of thumb. Heuristics are action scripts and tacit statements that serve to guide inspection rather than to prescribe it (Shirlina, Howard, Vetere, & Skov, 2004). They are used when a problem has been identified, but where an exhaustive search is impractical. Heuristics can be thought of as a shortcut, used to reduce the size of a problem space when seeking a solution (Gorman, 1998; Miller et al., 2015).

Bounded rationality. The expert recognizes that they possess limited capacity to evaluate options, for example, to render choices in urgent situations. In healthcare, expert nurses deal with this uncertainty by selecting a *sufficiently good* solution instead the single *best one* (Érdi, 2008; Thompson & Dowding, 2001).

Pattern recognition. Experts evaluate and anticipate by identifying distinctive features, or configurations of characteristics, that suggest a phenomenon (Miller et al., 2015; National Academies Press, 2006). Pattern recognition evaluates a circumstance, and assigns it salience, based on what has previously experienced. In a professional domain, pattern recognition necessitates a large body of directing knowledge (Gobet, de Voogt, & Retschitzki, 2004) and is a critical component of fluid expertise, because it precedes actions (Klein, 2008).

Introspection meta-cognition. The expert has developed the ability to subject his or her practice to self-scrutiny, even as it is being performed. This represents a sort of uncoupling or critical self-inspection about the adequacy of understanding. Meta-cognition means thinking about thinking. Nursing uses the concept r*eflective practice* to express this attribute (Benner, Stannard, & Hooper, 1996; Johns, 1999; Schon, 1983).

It is incorrect to assume that nurse knowledge workers can be identified in blanket fashion, on metrics such as experience and education. Rather, nursing knowledge work should be thought of as the aggregate of understanding, education, experience, pattern recognition, tacit knowledge, and other skills possessed by nurses who inhabit the healthcare system (Jost, 2012). This aggregate perspective conceptualizes nurse knowledge workers as a reservoir of deliberative

thought, available to supply the healthcare system at unpredictable times and in unpredictable ways (Jost, 2012). This research construct alleviates the need to predict when knowledge workers might deploy expertise. Thinking of knowledge work as an aggregate property, possessed by inhabitants of a complex system, helps conceptualize other confounders as well. For example, knowledge work is not static. Even jobs that are heavily dependent on novel deliberations are subject to the reengineering efforts of other knowledge workers. This results in cognitive stratification because cognitively rich jobs are constantly deconstructed into simpler processes, and distributed to technologies and paraprofessionals.

Clinical Decision Support Systems

Care providers are required to synthesize voluminous amounts of information—predominantly fragmented by discipline and medium (paper and electronic). This information overload is particularly true for acute care nurses, who are at the bedside 24 hours a day and expected to recognize patterns, communicate across the interdisciplinary team, and perform interventions prompted by collaborative decisions.

CDSSs are designed to support practitioners in their activities, by providing timely, seamless access to information, and guidance in the form actionable knowledge. More formally, CDSSs provide clinicians, staff, patients or other individuals with knowledge and person-specific information, intelligently filtered, and presented expediently (Harrington et al., 2011; Lee, 2014). Clinical decision support systems (CDSSs) encompass a variety of tools, such as computerized alerts and reminders, guidelines, order sets, patient data reports and dashboards, documentation templates, diagnostic support, and clinical workflow tools (Berner, 2016; Osheroff et al., 2006).

CDSSs, which synthesize large amounts of patient information, are considered essential to healthcare transformation and are presupposed to support clinical practice decisions (Chaudhry, 2008). Few rigorous studies, however, substantiate this relationship. Existing studies

are primarily concerned with user satisfaction (Ammenwerth et al., 2006; El-Kareh et al., 2009; Sockolow et al., 2009; Sockolow et al., 2011), and factors that promote or inhibit adoption (Ludwick & Doucette, 2009; Randell & Dowding, 2010; Russ et al., 2010; Saleem et al., 2009; Whittaker, Aufdenkamp, & Tinley, 2009a). Many studies have been focused on select diagnoses and specific care delivery environments (Cleveringa et al., 2008; Lyerla et al., 2010; Romano & Stafford, 2011). The findings from these studies have provided a mixed understanding CDSS impact on clinician performance and/or patient outcomes. Systematic reviews of CDSSs have yielded similar results (Bright et al., 2012; Garg et al., 2005; Jaspers, Smeulers, Vermeulen, & Peute, 2011). The limited focus of this research restricts generalizability—and contributes marginally to understanding how knowledge workers use systems in the clinical setting. Notably, there is also evidence that CDSS tools are not always used when available, with up to 96% of alerts being disregarded by physicians (Eccles et al., 2002). Equivalent studies examining CDSS in nursing workflow are lacking.

Technology and the Practice Environment

The practice environment is defined as the aggregate of the conditions, influences, forces, and cultural values that influence or modify an individual's life in a community such as a clinical unit. Magnet® designated facility research has correlated positive nurse perceptions of their work environment with better satisfaction, retention, and professional development (Kramer & Schmalenberg, 2004a; Kramer & Schmalenberg, 2004b; Kramer, Schmalenberg, & Maguire, 2004c; McClure, Poulin, Sovie, & Wandelt, 1983). Positive nurse reports of the practice environment have also been associated with lower patient mortality and failure-to-rescue (Aiken, Clarke, Sloane, Lake, & Cheney, 2008). From the literature, we know that knowledge workers often create knowledge, not in isolation, but through dialogue with others who may have differing perspectives (Benner et al., 1997). Qualitative studies have shown that knowledge workers use information technology, sometimes referred to as "discursive agents," to facilitate collective

dialogue which often spurs unexpected innovation (Brooks & Scott, 2006; Kogan & Muller, 2006; Quinlan, 2009; Swarts, 2008; Thomas et al., 2007; Yan, 2005). The impact of introducing an EHR and CDSS into the clinical practice environment is unknown and in urgent need of study. Additional research is needed to determine whether CDSS effectively promote collaboration, in-person or virtual, and how to most naturally integrate the technology into the practice environment. This integration must be viewed through a more nuanced lens than solely device placement and user acceptance. Instead, research should focus on whether these systems create virtual space for shared decision-making that generates novel solutions to complex clinical problems. The instruments used in this study, the Impact of Health Information Technology (I-HIT) and Essentials of Magnetism II (EOM II) enquire about and quantify, using Likert scales, nurses' perceptions about how technology impacts their autonomous decision-making, interdisciplinary relationships, and processes for virtual collaboration and communication. The results from this study provide a starting point from where this science can be further developed.

Conceptual Framework

This study was guided by Mitchell and colleagues' Quality Health Outcomes Model (QHOM) (Mitchell, Ferketich, & Jennings, 1998). The QHOM model, presented in Figure 2.1, seeks to explain relationships between the system, client, interventions, and outcomes by evaluating the characteristics of model concepts. For example, when considering *System,* hospitals would be evaluated with respect to size, location, academic affiliation, Magnet® designation status, staffing metrics, and technological sophistication. Nurses would be evaluated by experience, expertise, level of education attained, as well as other demographic considerations.

The QHOM represents an expansion of Donabedian's linear *structure, process, and outcome* model by recognizing the dynamic, multidirectional nature of the healthcare environment, nursing practice, and all its relevant components (Mitchell et al., 1998). The broad

lens offered by the QHOM, benefited this dissertation because it framed not only the relationship between the study intervention (CDSS implementation) and the outcome (nurses' perceptions of their knowledge work and the practice environment), but also included the potentially influential contextual factors, *System and Client* for consideration. Inasmuch as patient outcomes were not directly measured in this study, *Client* was, nonetheless, germane and provided guidance to this study. Specifically, patients and their families are inextricably tied to nursing practice and the healthcare delivery work environment. Patients are the de facto subject of all CPGs, documentation, interventions, and interdisciplinary communication contained within, and facilitated by, the CDSS; and nurses consider patients and families when evaluating interventions, such as a CDSS implementation, that impact on their ability to perform aspects of knowledge work and on their practice environment.

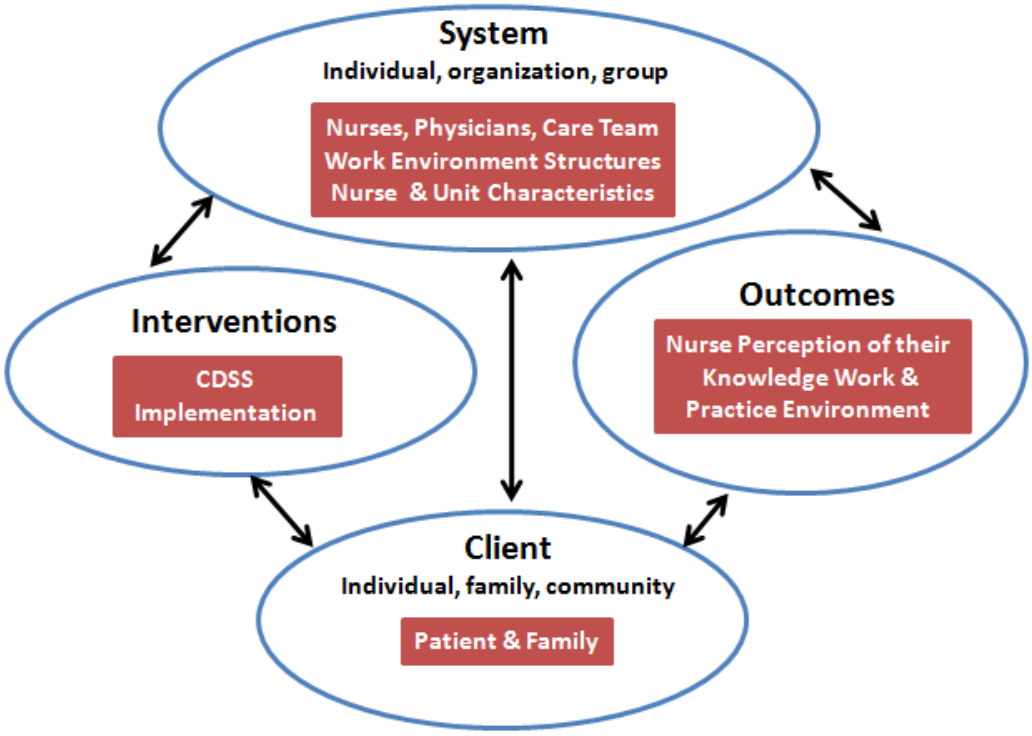


*Figure 2.1.*Quality Health Outcomes Model (QHOM) and relationship to study variables

Table 2.1 specifies the relationship between each QHOM concept, the associated study variable(s), the source of measurement, and the corresponding specific aims.

Table 2.1

Study Variable Alignment with Conceptual Model

Concept	Variable	Measured By	Aim Addressed
Intervention	*Independent:* Introduction of a CDSS into the organization (nursing practice environment)	Date of CDSS implementation Go-Live: June 9, 2011	Aims 1&2
System	Potential Explanatory Covariates: *Nurse:* Age, clinical ladder, experience, educational level, ethnicity, gender, hours worked per pay, prior experience with electronic documentation system, race, shift worked, tenure.	Nurse Demographic Survey	Aims 1&2
	Unit Type: Mixed Med-Surg., Medical, Surgical, Intermediate Intensive Care Unit, Emergency / Observation, Women's Health	Nurse Demographic Survey	Aims 1&2
	Staffing Metrics: Direct Care Hours Per Patient Day (DCHPPD), RN turnover	HUP Finance& Human Resource data	Aims 1&2
Client	Potential Explanatory Covariates: Patient Age, acuity	Not directly measured	Not directly addressed
Outcome	*Dependent:* Nurses' perceptions of their ability to perform aspects of knowledge work and of the nursing practice environment	I-HIT & EOM II	Aims 1&2

CHAPTER 3: STUDY DESIGN AND METHODS

Overview of the Study Design

A quasi experimental, pre-post research design was used to study the impact of a CDSS on nurses' perceptions of their ability to perform aspects of knowledge work, and on their perceptions of the clinical practice environment. Two valid and reliable survey instruments, the Impact of Health Information Technology Scale© (I-HIT) and the Essentials of Magnetism II© (EOM II) were used to measure nurses' perceptions of their ability to perform aspects of knowledge work and of the practice environment, respectively.

Studying implementation of information technology in a healthcare setting is inherently complex secondary to the researcher's inability to randomize direct care nurses or hospitalized patients to groups with or without the implemented CDSS. The tremendous variability between healthcare organization systems and structures (size, location, for-profit status, academic affiliation, workforce characteristics, institutional policies, and technology systems), often make it impractical or not feasible to identify organizations to serve as meaningful control groups. These variables, compounded with rapidly advancing technology, make achieving true experimental design when comparing information technology systems particularly challenging. Many healthcare information technology systems are integrated with a patient database—allowing historical control (pre- post- design) to be a widely accepted evaluation method (Friedman & Wyatt, 2006).

A baseline nurse perception measurement was obtained via electronic survey one month prior to CDSS implementation. A second measure was obtained at eight months post-implementation. The literature has demonstrated that measurement six month post-implementation is the minimum time required for the environment to stabilize, and also to be the point at when a change can be detected (El-Kareh et al., 2009; Sockolow et al., 2011). Since the

research on CDSS support of knowledge work is nascent, optimal measurement timing and expected effect size were extremely challenging to predict.

The strength of this design was that for nurses who completed both phases of the survey, (the paired sample), each nurse served as his/her own control. Nurses completing both the pre- and post- observations were matched—allowing some of the potential limitations of inherent variation in individual nurse perceptions to be addressed. A unique numeric identifier was assigned to every potential participant prior to survey distribution. In order to match participants, this unique identifier was correlated with each individual's response during both the pre- and post- survey administrations (see *Registered Nurse Enrollment and Data Collection* for a full description of the participant matching procedure). The research study design is illustrated in Figure 3.1.

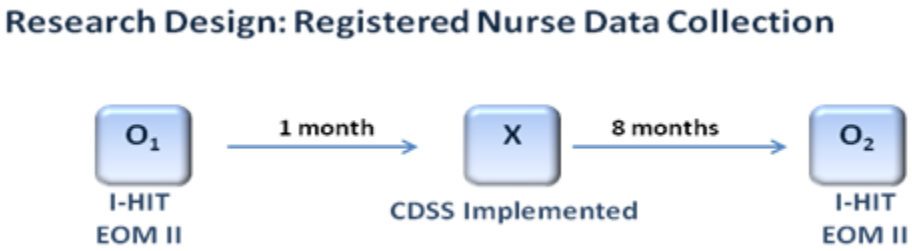


Figure 3.1. Research Study Design

Study Site

The study was conducted at the Hospital of the University of Pennsylvania (HUP). HUP is a 704-bed, academic, quaternary acute care Level 1 trauma center located in Philadelphia, PA. HUP serves adult patients and provides high end specialty care, including cardiovascular, transplant, neurology /neurosurgery and trauma. HUP has been a Magnet® designated institution since 2007.

Study Site Clinical Decision Support System Description

This study examined the implementation of a CDSS system produced by a leading healthcare software vendor. The CDSS is comprised of an integrated suite of computerized provider order entry (CPOE), laboratory, interdisciplinary clinical documentation, and a medication management module, all embedded with clinical decision support content and functionality. The system is designed to coordinate care across locations and departments, support critical decision-making, and automate processes for accuracy and safety. The systems' decision support is provided through practice knowledge in the form of evidence-based order sets and clinical practice guidelines (CPGs), reminders, and alerts incorporated into the interdisciplinary clinical documentation and order-entry content.

Power Analysis

Sample size was calculated using Power Analysis and Sample Size Software (PASS) (Hintze, 2011) for each specific aim. Statistical power for the required RN sample was estimated for Aim 1 and 2, which specified paired and independent samples t-tests for specific aim 1, and repeated measure and univariate general model regression (GLM) to predict differences in nurse perception related to fifteen theoretically predictive variables for specific aim 2. General Linear Model regression was used to test each variable's ability to predict for variance in the outcomes, while controlling for the other independent variables. A sample size of 406 achieved a power of 0.8 to detect an R^2 of 0.02 attributed to 1 independent variable using an F statistic with a significance level of 0.004. The novel nature of this proposed research precluded using preliminary, pilot or preexisting study data to establish effect size. In such cases, selection of a conservative effect size of 0.2 was considered prudent (Polit & Beck, 2010).

To address the threat of significant attrition due to the eight month time lapse between the pre- and post-implementation survey administrations, oversampling was used. A worst-case-

scenario potential attrition rate of 50% required oversampling by 203 nurses. Therefore, the total sample size required of 609 (406 + 203) provided sufficient power to detect variance while correcting for the anticipated attrition. Approximately 1,500 nurses met the inclusion criteria and were sent the survey. The required sample represented a 44% return rate—within the range of the organization's response rate for similar surveys.

Sampling Method

The survey was distributed, using a convenience sampling technique, to all direct care nurses, approximately 1,500, practicing on the 29 patient care units where the CDSS was implemented. Areas where the CDSS could not meet specific workflow needs, and where specialty systems pre-existed, were the few exceptions to the broad CDSS implementation.

Power calculations called for a large initial sample due to the threat of attrition with a longitudinal, pre-post-research design; projected conservative effect sizes; and the well-established challenges posed by survey response rates.

The study produced two sample groups: paired and independent. The paired sample was comprised of those RNs who completed both phases of the survey and whose responses were matched via the procedures described below. The independent sample consisted of those RNs who completed either the pre- or post-implementation survey, but not both.

Registered nurse inclusion criteria. To be eligible for this study, subjects were actively employed in direct care Registered Nurse (RN) positions on units where the CDSS system was being implemented. Licensed Practical Nurses (LPNs) were not employed on any of the 29 patient care units targeted for the study. RNs of all levels of tenure and clinical practice expertise level defined by the HUP Career Advancement and Recognition Program (CARP) (Clinical Ladder Level 1 novice through Level IV expert) were included (Benner, 1984). RNs holding various academic degrees were targeted for enrollment. HUP is characterized by a predominantly

(approximately 87%) Bachelor of Science in Nursing (BSN) or above prepared workforce. RNs of all full-time equivalent (FTE) status (per diem, part time, full time) were also included. Language diversity was not a consideration as all RNs were required to fluently speak and understand written English as a condition of employment.

Registered nurse exclusion criteria. RNs working in clinical areas where the CDSS was not implemented were excluded and not sent the survey. These excluded areas were the Emergency Department, Operating and Recovery Rooms, Neonatal Intensive Care Unit, procedural and ambulatory areas. RNs performing non-direct care positions, such as Nurse Managers (NM), Advanced Practice Clinical Nurse Specialists (CNS), Professional Development Specialists (PDS) and other administrative roles were excluded from the study.

Registered Nurse Enrollment and Data Collection

Recruitment of HUP nurses began three weeks before data collection for both the pre-and post-implementation measurements. Methods to recruit participants included: a) A letter from the principal investigator introducing the study and inviting participation was e-mailed to potential RN respondents (see Appendix A); b) flyers were posted in units where the CDSS was implemented; and c) the principle investigator (PI) attended Shared Governance Unit Council, patient care unit staff, and nursing leadership meetings to solicit support and encourage participation. Survey instruments were electronically distributed via e-mail with a link to the survey form. Data management was accomplished using Research Electronic Data Capture (REDCap) software tool hosted by The University of Pennsylvania School of Medicine. REDCap is a secure, web-based application designed to support data capture and storage for research studies (Harris et al., 2009). Each nurse was assigned a unique, system-generated identifier to allow tracking for the post-implementation matched sample measurement.

After IRB approval was obtained, a list of currently employed RNs, sorted by unit and position title, was obtained from the study site. The list was received in an Excel format and included: employee name, institutional e-mail address, employee identification number (EID), position title, job code, unit name, and accounting unit. The EID is a unique number assigned to each employee upon hire. This number remains constantly associated with that unique employee despite any subsequent name, position, or unit change.

Prior to each survey administration, the EID for each RN currently employed on the included units was associated with a researcher-assigned unique identification number (ID).This Excel file containing the EID and employee name associated with the researcher-assigned unique ID, was kept outside of REDCap on a secure Penn Medicine network drive. The researcher-assigned ID was associated with the employee institutional e-mail address in REDCap. When an RN received the survey and chose to participate by completing and returning the survey, this unique researcher-assigned numeric ID (one through approximately 2,000) was stored with their responses in the REDCap database. Individual RN response data could not readily be associated with any identifying information; only the investigator had the ability to associate the identifying information back to each RN's individual responses.

Data collection occurred over a period of approximately three weeks for both survey administration points (immediately prior to and eight months post CDSS implementation). All eligible RNs on included units were e-mailed the survey via REDCap that included a message that briefly introduced the study, the investigator's role as a PhD student, and invited them to participate voluntarily (see REDCap Greeting in Appendix B). The e-mail included a link that immediately directed the participant into the REDCap survey if clicked. The RN was neither required to remember any unique identifiers, nor were they required to log in. REDCap associated the investigator-assigned unique numeric ID with their e-mail address in the database table.

By completing the survey, the RN provided consent and enrolled. Participation was entirely voluntary (see the REDCap Included Informed Consent in Appendix C). REDCap had the ability to track survey completion and generate reminders to those who had not yet participated. Such reminders were sent approximately one to two times per week, and also included updates on progress toward study recruitment goals, deadlines for prize raffles, and other upcoming study incentives.

Incentives were directed only to direct care RN participants, and excluded nursing leadership. During both study phases, fifteen gift cards, valued at 25 dollars each, were raffled off weekly to promote study visibility and encourage participation. Three grand prizes (i.e. two Kindle e-readers, one iPad) valued at approximately 300-500 dollars each, were awarded throughout each enrollment period. Only participants who completed all survey responses were eligible for raffle prizes. All items in the survey were mandatory fields. If an RN skipped an item, REDCap prompted the participant with the number of the missed item when they attempted to save and close the survey. If a participant chose to close out of the survey without completing all items, the completed data were stored in the database. Missing responses were easily identifiable and REDCap contained functionality to allow identification of incomplete surveys.

REDCap provided the ability to export an Excel file of respondents who completed all survey questions and prize winners were selected from this list by using the random number function in Excel. The researcher-assigned ID was associated back to the EID and the institutional e-mail address to identify and notify the prize winners. Prize winners were contacted directly by the researcher. Prize winners were given three options for prize delivery: 1) to their home via US mail if the RN was agreeable to providing their home address, 2) to them personally at a HUP location, and 3) to their unit nursing leadership with the RN's explicit consent.

The investigator also provided catered meals in a conference room outfitted with a bank of six laptops where eligible RNs were invited to complete the survey during their shift meal

break. The number of these meals during each survey administration was determined by the level of participation and progression toward enrollment goals.

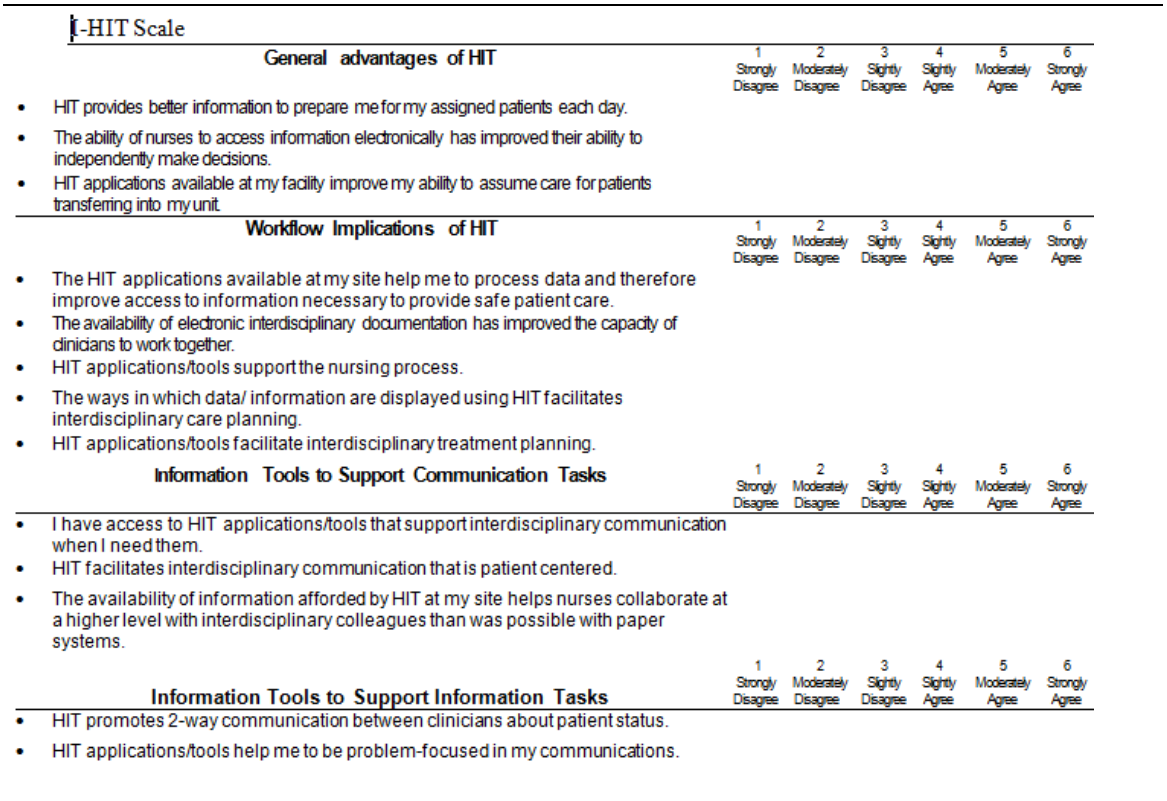
Instruments

Nurse perceptions of the CDSS impact on nurses' perception of their ability to perform aspects of knowledge work, and on the practice environment were measured using the Impact of Health Information Technology (I-HIT)© (Dykes et al., 2007; Dykes et al., 2009) scale and the Essentials of Magnetism II (EOM II)© (Kramer & Schmalenberg, 2004; Schmalenberg & Kramer, 2008).

The Impact of Health Information Technology (I-HIT). The I-HIT as developed by (Dykes et al., 2007) is comprised of 29 questions and 4 subscales. The subscales are: *General Advantages of HIT; Workflow Implications of HIT; Information Tools to Support Communication Tasks; and Information Tools to Support Information Tasks.* Data from participants responding to the I-HIT scored responses on a 6-point Likert scale; 1 = *Strongly Disagree* to 6 = *Strongly Agree.* The response option, "not applicable" was treated as missing data. All I-HIT data items were included in subscale scores with each having equal weighting.

The I-HIT was employed in this study to measure nurses' perception of their ability to perform aspects of knowledge work, pre- and post-CDSS implementation. While the instrument's reliability and validity is explicitly designed to appraise the adequacy of hospital information technology, the appraisal evaluates important aspects of knowledge work. These include communication, teamwork, the use of information, and the most foundational knowledge work attributes— clinical autonomy and discretion. I-HIT Item-7, "*The ability of nurses to access information electronically has improved their ability to independently make decisions*" exemplifies this.

Moreover, the I-HIT measures nurse interactions with the CDSS in a manner that presumes nurses are endowed with clinical autonomy and discretion. The instrument items are structured—and the instrument answers are scored—in a way that endorses nurses as the arbiters of care. The focus of the instrument is to determine if health information technology supports nursing practice, and the instrument posits technology as the supporting partner in that relationship. Figure 3.2 provides select I-HIT items from each subscale that measure aspects of nurse knowledge work.



I-HIT Scale

General advantages of HIT	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree
• HIT provides better information to prepare me for my assigned patients each day.						
• The ability of nurses to access information electronically has improved their ability to independently make decisions.						
• HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.						
Workflow Implications of HIT	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree
• The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.						
• The availability of electronic interdisciplinary documentation has improved the capacity of clinicians to work together.						
• HIT applications/tools support the nursing process.						
• The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.						
• HIT applications/tools facilitate interdisciplinary treatment planning.						
Information Tools to Support Communication Tasks	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree
• I have access to HIT applications/tools that support interdisciplinary communication when I need them.						
• HIT facilitates interdisciplinary communication that is patient centered.						
• The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.						
Information Tools to Support Information Tasks	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree
• HIT promotes 2-way communication between clinicians about patient status.						
• HIT applications/tools help me to be problem-focused in my communications.						

*Figure 3.2.*Example of Impact of Health Information Technology (I-HIT)© Scale Items

The Essentials of Magnetism (EOM II). The Essentials of Magnetism II is a valid and reliable instrument designed to measure aspects of a healthy and productive nursing work environment (Kramer & Schmalenberg, 2004; Schmalenberg & Kramer, 2008). Over a 10-year

period, nurses in Magnet® designated hospitals consistently identified eight processes and relationships that supported their practice. Each process or relationship is measured by a subscale (Kramer & Schmalenberg, 2008b).

The EOM II has 58 questions and eight subscales. The subscales are: *RNMD Relationships* scored via a 4-point Likert Scale, scored from1 = *Not True for any MD's* to 4 = *True for Most MD's Most of the Time.* The subscales and response options for seven subscales are as follows: *Support for Education, Clinical Autonomy, Control Over Nursing Practice, Perception that Staffing is Adequate, Working with Clinically Competent Peers, Nurse Manager Support Index, and Patient-Centered Cultural Values* and are scored from1 = *Strongly Disagree to* 4=*Strongly Agree.* The *Nurse-Assessed Quality of Patient Care on Unit* is scored from 1= *Dangerously Low* to 10 = *Very High Quality.* The EOM II also calculates, via a proprietary algorithm, a total Essentials of Magnetism II score--titled the *Professional Practice Satisfaction* (*PPS*) score. The *PPS* measures the extent to which aggregate subscale scores align with the standards, which are derived from nurse samples drawn from Magnet® designated hospitals, identified as essential to a productive work environment (Schmalenberg & Kramer, 2008).

When scored, the EOM II has several items that are weighted. The weightings are proprietary (Kramer & Schmalenberg, 2015) are not released to investigators using this tool. Thirteen items are re-coded during the scoring process. Items one and four are scored at half the normal values so as not to overweight the teaching component of nurse-physician relationships (*RNMD)* subscale. Eleven items (questions 3, 5, 9, 11, 13, 16, 17, 23, 27, 29, and 33) are negative items and re-coded prior to analysis.

The EOM-II subscale Clinical Autonomy focuses on three areas: 1) the degree of independent decision-making in nurse-specific realms of practice; 2) the effect of bureaucratic rules and regulations on independent decision-making, and 3) the level of administrative support for autonomous decision-making (Schmalenberg & Kramer, 2008). Kramer and Schmalenberg

(2008) found that autonomous decision-making is frequently associated with rapidly changing situations made to address patient needs, such as life-saving emergencies, coordination and integration of patient care, and to prevent patient harm. Nurse-Physician relationships characterized by collaboration, trust, and productive communication have also been shown to be supportive of autonomy and productive work environments (Kramer & Schmalenberg, 2008c). Similarly, nurses reported that having clinically competent peers, a supportive nurse manager, and a patient-centered organizational culture, supported clinical autonomy and a healthy and productive work environment (Kramer, Maguire, & Schmalenberg, 2006; Kramer & Schmalenberg, 2008b).

The EOM II is an appropriate instrument to assess nurse knowledge workers' perception of their practice environment. All of the instrument subscales emphasize aspects of clinical autonomy, and deliberative decision-making. They also assess aspects of nursing practice which align generally with the attributes nursing knowledge workers possess, and they work they perform. Figure 3.3 highlights select EOM II items focusing on autonomous decision-making.

		True for most MDs, most of the time	True for some MDs, some of the time	True for 1 or 2 MDs on occasion	Not true for any MDs
6	Physicians treat nurses on this unit as *equals*. MDs need RNs' assessments/observations and RNs need MDs medical knowledge if together we are going to help the patient.				
		Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
11	Nurses here fear 'getting into trouble' or 'taking big risks' if they make independent, autonomous decisions.				
12	Autonomous nursing practice is facilitated because nurses 'feel' or know that nurse managers will support them.				
13	Staff nurses must obtain orders or consent from an authority source before making independent or interdependent decisions.				
14	On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decisions in those spheres where nursing overlaps with other disciplines.				
15	Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions.				
16	This organization has many rules and regulations that prevent nurses from making independent or interdependent decisions.				
19	There is a general understanding among nurses on my unit that nursing administration wants us to function autonomously.				
34	Nurses on my unit demonstrate a proficiency level of competence.				

Figure 3.3. Example of Essentials of Magnetism II (EOM II)© Items

Table 3.1, *Instrumentation Detail,* provides an overview of the instrument used to address each aim, number of items and subscales, and psychometrics. Both instruments have demonstrated solid reliability and validity with acute, direct care nurse samples. See Appendices D and E for I-HIT and EOM II instruments.

Table 3.1

Instrumentation Detail

Aims	Outcome Variable	Instrument	Method	Items & Subscales	Psychometrics
1 & 2	Impact of CDSS on nurse perceptions of their ability to perform aspects of knowledge work and the practice environment	I-HIT: Impact of Health Information Technology	Survey	29-Items 4 Subscales: 1. General Advantages 2. Workflow Implications 3. Support Communication Tasks 4. Support Information Tasks	Chronbach alpha internal consistency: 0.95; with subscales range from 0.8-0.89 *PCA w/ Varimax rotation
		EOM II: Essentials of Magnetism Essential processes that enable desired outcomes	Survey	58-Items 8 Subscales + 1 Single-item quality & 1 Total EOM II score: 1. RN-MD Relationships 2. Support for Education 3. Clinical Autonomy 4. Control over Nursing Practice 5. Adequate Staffing 6. Clinically Competent Peers 7. Nurse Manager Support 8. Patient-Centered Cultural Values 9. Nurse-Assessed Quality of Patient Care on Unit 10. Professional Practice Satisfaction / Total EOM II Score	Chronbach alpha internal consistency: 0.83-0.97 * PCA w/ Varimax rotation

* Principal Components Analysis

Participant burden to complete the 100 questions was estimated to be 20 to 25 minutes based on a pre-survey pilot testing exercise with 10 practicing RNs. Fifteen potentially influential nurse and clinical unit characteristic independent variables were collected and analyzed as

covariates for their ability to predict differences in the dependent outcome subscale variables. The time for completion was expected to vary depending on participant decision-making styles, motivation, and individual level of interest. However, the survey length was not a barrier because the REDCap functionality allowed nurses to begin the survey and complete it at a later time, if needed. Of note, HUP RNs have completed surveys for Magnet® designation of similar length and time burden. Survey response rates for these similar surveys have been above 80%.

Data Analysis Plan

SPSS Statistical Software, Version 23.0 was used for data analysis (IBM Corp., 2015).

Data Analysis by Aim.

Aim 1**:** Examine the impact of a CDSS implementation on nurses' perceptions of their ability to perform aspects of knowledge work and on the nursing practice environment.

H_0: There will be no change in the nurses' perceptions of their ability to perform aspects of knowledge work or their nursing practice environment, measured by the I-HIT and EOM II respectively, from baseline (pre-implementation) to eight months post-implementation.

Aim 2**:** Examine a set of nurse and patient care unit characteristic variables and their corresponding explained variance associated with nurses' perceptions of their ability to perform aspects of knowledge work and the nursing practice environment (measured by each I-HIT and EOM II subscale).

Aims 1 and 2 required that the I-HIT and EOM II instruments were administered twice, eight months apart. A two-tailed, paired *t*-test of differences in means was used for the paired sample; a two-sample independent *t*-test was used to analyze the independent sample. The potentially confounding variables, staffing, and turnover were analyzed for both research hypotheses using matrix line graphs for the entire 14-month study period. Pearson's and Spearman correlations were analyzed to determine the existence of any significant, potentially

influential, relationships between turnover, staffing, and the dependent outcome subscales at months six and 14 when the survey was administered.

Repeated measure and univariate general linear model (GLM) regression were used to identify significant predictor or explanatory variables for the variance in the dependent subscale outcomes while controlling for multiple independent variables. Baseline (pre-implementation) nurse characteristics were used as independent predictor variables in all regression models.

Multiple manual stepwise methods were used to examine the relative contributions of each variable relative to the dependent variables (subscale scores for the I-HIT and EOM II). Variables found to be at the 0.2 significance level or below were retained for further analysis. Those variables at the 0.2 level in simple models (one at a time) were examined on the basis of least significance until only those remaining that reached the 0.1 level were included in the final GLM regression models.

In repeated measure GLM regression models, *time* was included as a within-subjects factor, along with all predictor variables significant at the 0.2 level or below. Interactions between time and each predictor variable were also included in each model. Interaction and main effect variables were removed if the 0.1 level of significance was not attained by either the interaction or the main effect variable.

For the independent sample, *group* was included in univariate GLM models as a between subjects factor. Interactions were included for consideration if significant at the 0.2 level or below in simple models. Main-effect and interaction variables were removed sequentially based on least significance of 0.1 or below.

Based on the final models, it was possible to explain the amount of variance in the dependent measures accounted for by each variable and aggregate of variables. Table 3.2*, Variable Definitions and Data Analysis Plan,* outlines all dependent and independent variables by level of measurement, and specifies the data analysis plan by aim.

Table 3.2

Variable Definitions and Data Analysis Plan

Variable	Level of Measure	Definition	Analysis
Dependent Outcome Variables: Aim 1			
I-HIT GA	Continuous	General Advantages of HIT	Paired / Independent *t*-tests
I-HIT WF	Continuous	Workflow Implications of HIT	Paired / Independent *t*-tests
I-HIT SCT	Continuous	Tools to Support Communication Tasks	Paired / Independent *t*-tests
I-HIT SIT	Continuous	Tools to Support Information Tasks	Paired / Independent *t*-tests
I-HIT DPC	Continuous	HIT Depersonalizes Care	Paired / Independent *t*-tests
EOM RNMD	Continuous	Nurse-Physician collaborative patient care relationships	Paired / Independent *t*-tests
EOM SuppED	Continuous	Organizational support for RNs' pursuit of ongoing education	Paired / Independent *t*-tests
EOM AUTO	Continuous	Clinical Autonomy: Nurse ability to practice and make clinical decisions autonomously	Paired / Independent *t*-tests
EOM CNP	Continuous	Control Over Nursing Practice: Nurse's ability to exert influence over unit/organizational practice policies and decisions	Paired / Independent *t*-tests
EOM STAFF	Continuous	Perceived Adequacy of Staffing: to allow quality, safe patient care	Paired / Independent *t*-tests
EOM CCP	Continuous	Working with Clinically Competent Peers	Paired / Independent *t*-tests
EOM NMS	Continuous	Nurse Manager Support Index	Paired / Independent *t*-tests
EOM PCV	Continuous	Patient-Centered Cultural Values: Organizational structures and policies promote quality care	Paired / Independent *t*-tests
EOM PPS	Continuous	Professional Practice Satisfaction score (Total EOM II)	Paired / Independent *t*-tests
EOM QoC	Continuous	Nurse-assessed usual Quality of Care on unit	Paired / Independent *t*-tests

Variable	Level of Measure	Definition	Analysis
Independent Explanatory Variables: Aim 2			
Age	Discrete Continuous	▪ Years	Repeated Measures & Univariate GLM
Clinical Ladder	Categorical Ordinal	1. Levels 1 2. Level 2 3. Levels 3 & 4	Repeated Measures & Univariate GLM

Clinical Unit Type	Categorical	1. Mixed Med-Surg /Outpatient Observation 2. Medical 3. Surgical 4. Intermediate 5. Intensive Care 6. Women's' Health	Repeated Measures & Univariate GLM
Education	Categorical	1. Diploma & Associates 2. Bachelor 3. Master's & Doctorate	Repeated Measures & Univariate GLM
Education Outside of USA	Dichotomous	1. Yes 2. No	Repeated Measures & Univariate GLM
Ethnicity	Dichotomous	1. Hispanic or Latino 2. Non-Hispanic or Latino	Repeated Measures & Univariate GLM
Hours Per Pay	Discrete Continuous	▪ 0 hours to 160 hours / pay in 4 hour increments	Repeated Measures & Univariate GLM
Institutional (HUP) Tenure	Continuous	▪ Years	Repeated Measures & Univariate GLM
Institutional (HUP) Tenure_Coded	Categorical	1. 3 years or less 2. 3+ to 5 years 3. 5+ to 10 years 4. 10+ to 15 years 5. 15+ to 20 years 6. 20+ to 30 years 7. 30+ years	Repeated Measures & Univariate GLM
Prior electronic nursing clin. doc. experience	Dichotomous	1. Yes 2. No	Repeated Measures & Univariate GLM
Race	Categorical	1. Asian, Native Pacific Islander, Native American Indian or Alaskan 2. Black or African American 3. White or Caucasian	Repeated Measures & Univariate GLM
Sex	Dichotomous	1. Male 2. Female	Repeated Measures & Univariate GLM
Shift	Categorical	1. 8, 10 or 12 hour day shift 2. 8, 10 or 12 hour night shift 3. Rotate > 50% of shifts	Repeated Measures & Univariate GLM
Total Years Experience	Continuous	▪ Years	Repeated Measures & Univariate GLM
Total Years Experience_Coded	Categorical	1. 3 years or less 2. 3+ to 5 years 3. 5+ to 10 years 4. 10+ to 15 years 5. 15+ to 20 years 6. 20+ to 30 years 7. 30+ years	Repeated Measures & Univariate GLM

Human Subject Considerations

Survey studies have traditionally imposed minimal risk. The REDCap survey instrument contained statements of disclosure detailing the researcher's role as a PhD student and that participation was voluntary. Prior to the beginning the survey items, the RN participant was presented with informed consent disclosure information (see Appendix C). Choosing to participate was considered consent and no additional acknowledgement of consent was required. Subjects were provided contact information for the PI, and encouraged to express any concerns related to the study. Instructions on how to contact the nursing IRB representative for the organization and the Penn School of Nursing were included in the disclosure statement appearing ahead of the survey items. Concerns would have been regarded as cause to convene the PI's dissertation committee; however, the committee was not convened as no concerns were raised.

The time projected to complete the survey was not expected to be an undue burden as the HUP RNs were accustomed to completing National Database of Nursing Quality Indictors (NDNQI) RN Satisfaction surveys of similar length. Since the REDCap survey tool was delivered via e-mail and was web-enabled, eligible RNs were able to complete the survey from any personal computer (PC), Mac, and most Apple and Droid operable mobile devices. The ability to complete the survey outside of the work location served to protect the privacy of those RNs who preferred not to disclose their participation to colleagues or supervisors. Perhaps more important, the HUP nurse leaders fully endorsed this study, and were supportive of RNs completing the survey during normal work hours —recognizing that patient care responsibilities took priority.

All identifying demographic data were maintained in a secure Penn Medicine network drive. De-identified respondent data were stored in REDCap—away from the identifying data. Organizational leadership and study participants were not informed of study results until after study conclusion. All study findings will be reported in aggregate using de-identified data.

Table 3.3*, Targeted Registered Nurse Participation: Ethnicity, Race &Gender*, outlines the planned recruitment targets for ethnic, racial and sex/gender minority groups. No children or other vulnerable groups were involved in this research. Targets were established based on national benchmarks (U.S. Department of Health and Human Services, 2010). However, data from all eligible participants were accepted and analyzed. Respondent demographic data were elicited and tracked for the purposes of understanding the representativeness of the respondents. The *RN Demographic Data Collection Tool* is included in Appendix F. Since the survey was distributed electronically to all eligible RNs on the included units, the researcher was notable to feasibly target responses from any particular racial, ethnic, or sex/gender groups. All eligible RNs were recruited (via e-mail, staff and unit council meetings) in the same manner. Nursing leadership was not provided instruction to encourage participation from any racial, ethnic, sex/gender group in particular. Those who completed the survey during the first administration were encouraged, via e-mail communication, to participate again during the post-implementation survey.

Table 3.3

Targeted Registered Nurse Participation: Ethnicity, Race &Gender

	Sex/Gender		
	Females	Males	Total
Hispanic or Latino	20	1	21
Non-Hispanic or Latino	549	38	588
Ethnic Category: Total of all subjects	569	40	609
American Indian/Alaska Native	6	0	6
Asian	31	2	33
Native Hawaiian or Other Pacific Islander	0	0	0
Black or African American	31	2	33
White	500	35	539
Racial Categories: Total of all subjects	569	39	609

CHAPTER 4: RESULTS

Introduction

This study examined the impact of a Clinical Decision Support System (CDSS) on direct care registered nurses' (RNs) perceptions of their ability to perform aspects of knowledge work and perceptions of the practice environment with respect to the performance of aspects of knowledge work. A pre-post-study design was implemented to address the study aims. Two valid and reliable instruments, the Impact of Health Information Technology (I-HIT)Scale© (Dykes et al., 2007; Weaver, 2006) and the Essentials of Magnetism II© (EOM II) (Schmalenberg & Kramer, 2008) were administered, prior and subsequent to implementation of the CDSS, to RNs in direct care roles at the Hospital of the University of Pennsylvania (HUP). Descriptive and inferential statistical results are provided in this chapter, including a description of the study sample, instrument psychometrics, and results addressing each of the two specific aims. Selected results are displayed in tables.

Survey Response Rate

The pre and post-implementation surveys were e-mailed via The Research Electronic Data Capture software (REDCap), to direct care HUP nurses working on the 29 patient care units where the CDSS was implemented. For the pre-implementation survey, data were gathered over a 16-day period (June 9, 2011 to June 25, 2011), and for the post-implementation survey an 18 day period (February 7, 2012 to February 25, 2012). The response rate for the pre-implementation survey was 49.1% with 1,491 nurses receiving the survey and 735 responding, and 54.2% for the post-implementation survey with 1,515 nurses receiving the survey and 822 responding. Duplicate and incomplete surveys were examined resulting in 25 exclusions for the pre-implementation survey (n = 710) and 29 exclusions for the post-implementation survey (n = 793).

Characteristics of the Study Sample

Categorical demographic characteristics are shown in Table 4.1 for the paired, pre-only, and post-only samples. *Overall group*, for purposes of this demographic analysis, is defined as: participants who responded to both a pre- and-post-survey and participants who just responded to either the pre- or post-survey.

The overall group was predominantly Caucasian (76.5%), Non-Hispanic or Latino (96.9%) and female (90.1%). However, the survey sample was more diverse than expected. RNs from minority ethnic, racial and gender groups participated at rates higher than expected (Table 3.3, *Targeted Registered Nurse Participation: Ethnicity, Race & Gender*) based on national benchmarks (U.S. Department of Health and Human Services, 2010). Hispanic or Latino RN participation exceeded the target by 52.3% and represented 3.06% of the sample. African American and Asian/Pacific Islander/Native Americans also exceeded planned participation rates at 12.9% and 10.9%, and were represented in the sample at approximately twice the national average (5.4% and 5.8% respectively). Participation of male RNs exceeded planned rates in all categories.

For the overall group, 85% held a bachelor's degree. Participants prepared with either a master's or bachelor's degree accounted for 95% of the overall group, nearly twice the national average of 50% (U.S. Department of Health and Human Services, 2010). Nurses who reported obtaining their nursing education outside the United States comprised 11.5% of the sample, as compared with the national benchmark of 5.6% (U.S. Department of Health and Human Services, 2010).

Table 4.1

Categorical Registered Nurse (RN) Demographic Characteristics

Characteristic	Paired (n=458)		Pre-Only (n=252)		Post-Only (n=335)	
	f	%	*f*	%	*f*	%
Gender						
Female	415	90.6	226	89.7	308	91.9
Male	43	9.4	26	10.3	27	8.1
Age						
20-29	209	45.6	129	51.0	176	52.5
30-39	137	29.9	57	22.5	99	29.6
40-49	64	14	46	18.2	45	13.4
50-59	43	9.4	13	5.1	12	3.6
60+	5	1.1	8	3.2	2	0.6
Race						
White or Caucasian	359	78.4	178	70.6	258	77.2
Black or African American	50	10.9	42	16.7	43	12.9
Asian	43	9.4	30	11.9	33	9.9
Native Hawaiian or Other Pacific Islander	6	1.3	2	0.8		
Ethnicity						
Non-Hispanic or Latino	445	97.4	240	94.9	328	97.9
Hispanic or Latino	12	2.6	13	5.1	7	2.1
Education (Highest Degree Obtained)						
Associate	11	2.4	11	4.3	1	0.3
Diploma	8	1.7	8	3.2	4	1.2
Bachelor's	392	85.6	194	76.7	296	88.4
Master's	44	9.6	40	15.8	32	9.6
Doctorate	3	0.7			2	0.6
Education Outside of US (Yes)	50	10.9	34	13.4	37	11.0
Experience (Years) as an RN						
3 or <	162	35.4	85	33.6	144	43.0
3+ to 5	82	17.9	68	26.9	64	19.0
5+ to 10	76	16.6	39	15.4	56	16.7
10+ to 15	46	10.0	17	6.7	30	9.0
15+ to 20	35	7.6	21	8.3	18	5.4
21+ to 30	37	8.1	14	5.5	17	5.1
30+	20	4.4	9	3.6	6	1.8
Experience (Years) at this Institution						
3 or <	214	46.7	116	45.8	189	56.4
3+ to 5	85	18.6	60	23.7	63	18.8
5+ to 10	74	16.2	41	16.2	48	14.3
10+ to 15	30	6.6	11	4.3	20	6.0
15+ to 20	21	4.6	13	5.1	5	1.5

21+ to 30	25	5.5	10	4.0	8	2.4
30+	9	2.0	2	0.8	2	0.6
Career Clinical Ladder Level						
Level 1	90	19.7	39	15.4	95	28.4
Level 2	258	56.3	169	66.8	201	60.0
Level 3	80	17.5	41	16.2	33	9.9
Level 4	30	6.6	4	1.6	6	1.8
Clinical Unit Type						
Mixed Medical-Surgical	45	9.8	28	11.1	30	9.0
Medical	88	19.2	43	17	60	17.9
Surgical	89	19.4	45	17.8	75	22
Emergency / Observation	25	5.5	14	5.5	34	10.1
Intermediate	50	10.9	32	12.6	30	9.0
Intensive Care	131	28.6	72	28.5	82	24.5
Women's Health	30	6.6	19	17.5	24	7.2
Shift Usually Worked						
8/10 hour days	17	3.7	8	3.2	12	3.6
12 hour days	215	46.9	121	47.8	148	44.2
8/10 hour nights	5	1.1	4	1.6	4	1.2
12 hour nights	134	29.3	76	30	95	28.4
Rotate 50% of shifts	87	19	44	17.4	76	22.7
Average hours worked per pay period (2 weeks / 80 hours)						
23 or <	11	2.4	16	6.3	16	4.8
24 – 47	81	17.7	52	20.6	62	18.5
48-71	23	5	15	5.5	18	5.4
72 or >	343	74.9	171	67.6	239	71.3
Prior experience with electronic nursing clinical documentation system (Yes)	181	39.5	92	36.4	160	47.8

f = Frequency

Participants ranged in age from 20 to 73 years with a mean age of 33 years, younger than the national RN average of 47 years (U.S. Department of Health and Human Services, 2010). Participants had 8.0 years of experience as an RN (range 0.5 to 53 years), and institutional tenure of 5.64 (range 0.5 to 40 years). The majority worked full-time, accounting for 71.9% of participants. The overall group was dispersed across clinical units; intensive care unit 27.2%, surgical 20.0% and medical 18.3%.

Nurses were asked about their experience with electronic nursing clinical documentation systems to ascertain familiarity with using a computer interface to document assessments, interventions, and notes about patients' conditions. A negative response--no experience prior to working at HUP--indicated either a new nurse who had never worked at another hospital, or a nurse who prior to working at HUP, had only used paper-based charting. More than half of the overall group indicated that they had had no experience, prior to working at HUP, with an electronic nursing clinical documentation system. Those who indicated no prior experience with electronic nursing clinical documentation systems had an average of 9.42 years of RN experience, and those with prior experience had an average of 7.09 years of RN experience.

Psychometric Evaluation

Impact of Health Information Technology (I-HIT) Scale

Instrument Description

The *Impact of Health Information Technology (I-HIT) Scale* was designed to measure nurses' perceptions about the ways HIT impacts their role as integrators of interdisciplinary care, repositories of data, and communicators of patient information across the care continuum, which are components of nursing knowledge work. The I-HIT also measures nurses' perceptions of the impact of HIT on nursing practice workflow, as well as nurses' satisfaction with the HIT applications available to them in their work environment (Dykes et al., 2007).

An exploratory principal component factor analysis (EFA) was performed on the I-HIT in order to examine whether the instrument factor structure, when administered to another sample of RNs, would replicate the original I-HIT psychometric study findings (Dykes et al., 2007). The use of the I-HIT in a pre-post implementation research study design also fulfilled a recommendation put forth by the originators of the I-HIT. The sample ($N = 733$) used for this factor exploratory analysis was RNs from both the pre-implementation paired and independent group samples. This sample size exceeded the recommended number of respondents, more than 10 per item, determined to be adequate to perform a principal component factor analysis (Munro, 2005).

Description of the Sample

The HUP sample was similar to the original Dykes et al. (2007) psychometric evaluation sample in that respondents were mostly female, and were more educated than the national average. The HUP sample, however, was considerably younger and less tenured in their positions than the Dykes et al. (2007) sample. The HUP sample was also comprised entirely of direct care nurses employed at an academic medical center as compared with the Dykes et al. (2007) sample

where 68.1% reported being from a medical teaching hospital. Table 4.2 provides a comparison of the HUP and Dykes et al. (2007) psychometric study sample characteristics.

Table 4.2

Sample Characteristic Comparison: HUP and Dykes et al. 2007 Psychometric Analysis

Sample Characteristic	HUP* %	Dykes et al. 2007 %
Gender: Female	90.6	91.3
Education: Bachelor's degree or higher	94.6	72.6
Age: Over 40 years old	20.8	73.1
Total nursing experience: > 20 years	10.0	51.1
Role: Direct care provider	100	48.5

*HUP = Hospital of the University of Pennsylvania

Factor Analysis

An EFA with a varimax (orthogonal) rotation was performed using all pre-implementation HIT data responses to the 29 items. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO = 0.950) and Bartlett's Test of Sphericity (6,896.04, $p < 0.001$) verified that the data met criteria for a factor analysis. The final sample, after cases with any missing response data were eliminated, equaled $n = 439$. This represents an elimination of 294 cases (40% of the pre-implementation sample) that had at least one response missing. The Dykes et al. (2007) psychometric evaluation included cases with 10% or less missing data and required elimination of 38.6% of survey sample responses to obtain the 1,079 cases in the final sample.

The varimax rotation, which assumes a level of independence of the constructs, produced 5 factors with Eigen values >1 accounting for over 60% of the variance. The rotation converged in 9 iterations. The 5 factor structure, presented in Table 4.3, represents a departure from the original 4 factor I-HIT structure published by Dykes et al. (2007), where item 11, *HIT*

Depersonalizes Care, loaded with seven other items on the *Workflow Implications of HIT* subscale. In this replication study, Item 11, *HIT Depersonalizes Care,* loaded as a single factor resulting in a fifth subscale.

Once the factor structures with similar subscales were confirmed, internal consistency reliability was measured for each subscale. Cronbach's alpha for each subscale were as follows: *General Advantages of HIT* subscale, $\alpha = .84$; *Workflow Implications of HIT* subscale, $\alpha = .88$; *Information Tools to Support Communication Tasks* subscale, $\alpha = .77$; *Information Tools to Support Information Tasks* subscale, $\alpha = .88$. Since the *HIT Depersonalizes Care* subscale is comprised of a single-item, it was not possible to obtain a Cronbach's alpha value.

Table 4.3

Principal Component Analysis for the Impact of Health Information Technology (I-HIT) Scale with Varimax Rotation and Kaiser Normalization (N = 439)

Variance explained by five factors: 60.47%	Component				
	1	2	3	4	5
General Advantages of HIT (15.28% Variance, Eigenvalue = 4.43, Cronbach's α = .844)					
1.) HIT applications/tools have decreased the time I need for end of shift report.	.136	.602	.434	-.252	-.033
2.) HIT applications have decreased the need for direct communication around writing patient orders.	-.057	.626	.099	.115	.486
3.) HIT provides better information to prepare me for my assigned patients each day.	.181	.705	.156	.234	-.123
4.) HIT facilitates practice efficiency.	.248	.677	.248	.117	-.133
5.) HIT allows for patient/family participation in care.	.394	.295	.463	-.055	.201
6.) The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone.	.456	.382	.067	.126	.500
7.) The ability of nurses to access information electronically has improved their ability to independently make decisions.	.380	.539	.154	.169	.196
8.) HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.	.334	.561	.098	.299	.105
9.) Work lists generated from HIT tools support efficient patient care.	.416	.505	.182	.295	-.063
Work Flow Implications of HIT (17.98% Variance, Eigenvalue = 5.21, Cronbach's α = .888)					
10.) The ways in which data/ information are displayed using HIT improves access to data.	.378	.583	.173	.295	-.087
12.) The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.	.372	.517	.156	.369	-.096
13.) The availability of electronic interdisciplinary documentation has improved the capacity of clinicians to work together.	.665	.360	.283	-.037	-.070
14.) HIT applications/tools support the nursing process.	.553	.421	.321	.170	-.195
15.) The ways in which data/ information are displayed using HIT reduces redundancy of care.	.655	.187	.210	-.039	.069
16.) The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.	.768	.148	.247	.146	-.067

17.) HIT applications/tools facilitate interdisciplinary treatment planning.	.746	.169	.302	.183	-.003
23.) The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.	.512	.393	.275	.187	.081
Information Tools to Support Communication Tasks (8.12% Variance, Eigenvalue = 2.35, Cronbach's α = .777)					
18.) My site is utilizing HIT strategies to optimize interdisciplinary communication (e.g. clinical messaging, Vocera or similar wireless voice communication system, text paging).	.355	-.006	.310	.440	.178
19.) Available HIT applications/tools facilitate the process of patient tracking.	.153	.234	.071	.694	.006
20.) I have access to HIT applications/tools that support interdisciplinary communication when I need them.	.452	.144	.416	.503	-.022
21.) Available HIT tools support both patient care and administrative processes.	.589	.265	.275	.358	-.037
22.) HIT facilitates ID communication that is patient centered.	.594	.149	.336	.363	.033
24.) I know how to access the HIT applications/tools available in the electronic medical record system.	-.059	.318	.146	.565	-.278
Information Tools to Support Information Tasks (14.73% Variance, Eigenvalue = 4.27, Cronbach's α = .884)					
25.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that my interdisciplinary colleagues have received the communications that I send.	.199	.182	.750	.171	-.016
26.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that interdisciplinary colleagues have acted upon information that I send.	.244	.186	.784	.107	.062
27.) HIT promotes 2-way communication between clinicians about patient status.	.326	.094	.757	.121	.060
28.) Communication of critical events to interdisciplinary colleagues can be done effectively using HIT.	.194	.170	.738	.133	.121
29.) HIT applications/tools help me to be problem-focused in my communications.	.355	.266	.628	.201	.028
HIT Depersonalizes Care (4.37% Variance, Eigenvalue = 1.29)					
11.) * HIT depersonalizes care.	.102	.174	-.144	.139	-.666

* Reverse coded item

1. Extraction Method: Principal Component Analysis.
2. Rotation Method: Varimax with Kaiser Normalization.
3. Rotation converged in 9 iterations.

An intercorrelation matrix constructed for the I-HIT subscales using the revised 5 factor structure is presented in Table 4.4. The four original subscales were moderately correlated with the other subscales (*r* values ranging from .540 to .713). The *HIT Depersonalizes Care* subscale had extremely low correlation coefficients (.001 to .154) with other subscales. The moderate level of correlation among the original four subscales demonstrates either that there is a level of conceptual overlap among the constructs or these co-vary with one another.

Table 4.4

Intercorrelation Matrix of Subscales for Pre-Implementation Sample

I-HIT Subscales	HIT GA	HIT WF	HIT SCT	HIT SIT	HIT DPC
General Advantages of HIT (*HITGA*)	1				
Work Flow Implications of HIT (*HITWF*)	.701**	1			
Information Tools to Support Communication Tasks (*HITSCT*)	.631**	.713**	1		
Information Tools to Support Information Tasks (*HITSIT*)	.540**	.634**	.612**	1	
HIT Depersonalizes Care (*HITDPC*)	.085*	-.087*	.154**	.001	1

r = Pearson's Correlation Coefficient
Correlation is significant at the 0.01 level (2-tailed).**
Correlation is significant at the 0.05 level (2-tailed).*

The psychometric replication performed in this study produced the five factor structure; accordingly, the five factor solution was used for statistical analysis of the I-HIT to address Specific Aims 1 & 2.

Reliability Analysis

Internal consistency reliability measured by Cronbach's alpha was assessed for all I-HIT items for the three sample groups: Paired, pre-implementation, and post-implementation. Cronbach alphas consistent with the published psychometrics (Dykes et al., 2007), are shown in Appendix G, Tables G 4.1 through G 4.3. The paired sample group had an overall Cronbach's alpha of .936. Cronbach's alphas were examined for relative changes if any one item was deleted.

No appreciable changes (range .93 to .94) were found in the overall Cronbach's alpha if any individual items were removed; therefore, all items were retained for analyses. Data from the pre-implementation independent group overall Cronbach's alpha of .949 with item deletion alphas remaining around .950 across all items. Similarly, the post-implementation independent sample had an overall Cronbach's alpha of .968 with no item deletion values warranting the removal of any item.

I-HIT Subscale Intercorrelations

The I-HIT paired sample demonstrated moderate to strong subscale intercorrelations in four of the five subscales in both the pre- and post-implementation samples. Pearson's Product Moment coefficients ranged from $r = .520$ ($p = < .001$) between *General Advantages of HIT (HITGA)* and *Information Tools to Support Information Tasks (HITSIT)*, to $r = .861$ ($p = .001$) between *HITGA* and *Workflow Implications of HIT (HITWF).*The single-item subscale, *HIT Depersonalizes Care (HITDPC),*demonstrated weaker correlations across the pre- and post-implementation samples, ranging from $r = -.009$ ($p = .854$) with *HITSIT*, to $r = .424$ ($p = < .001$) with *HITGA.*

The I-HIT independent sample demonstrated subscales correlations consistent with the paired sample, ranging from $r = .566$ ($p < .001$) between *Information Tools to Support Communication Tasks (HITSCT)* and *HITSIT*, to $r = .860$ ($p = < .001$) between *HITGA* and *HITWF*. The independent sample group correlations for subscale *HITDPC* were also consistent with the paired sample findings, demonstrating weak correlations that ranged from $r = -.011$ ($p = .874$) with *HITSIT*, to $r = .331$ ($p = < .001$) with *HITWF*. The *HITDPC* subscale demonstrated the weakest relationships overall. Appendix H Tables 4.1 through 4.4 provides the Pearson's subscale intercorrelations for the I-HIT.

I-HIT Item Descriptive Statistics: Pre-and-Post Implementation Mean Difference Scores

I-HIT survey question 4, "*Health Information Technology facilitates practice efficiency*" had the largest mean difference for both the independent and paired sample. The paired mean difference was .96 and the independent mean difference was .70, correlating with decreased satisfaction. Six of the same I-HIT questions populated the paired and independent top 10 mean differences. These questions were associated with the *General Advantages* and *Workflow Implication of HIT* subscales, and accounted for a range of decreased satisfaction in I-HIT items from .47 to .96. All I-HIT items, for both the paired and independent samples, showed a decrease in satisfaction, except for Item-24, "*I know how to access the HIT application/tool available in the electronic medical record system*." Fifty percent of the items on the paired survey responses decreased at least one half of a Likert scale point, while 24% of survey items for the independent group decreased at least one half of a Likert scale point. Pre- and post-implementation I-HIT mean difference scores are detailed in Appendix I Tables 4.1 and 4.2 for the paired and independent samples respectively.

Specific Aim 1

Aim 1: Examine the impact of a CDSS implementation on nurses' perceptions of their ability to perform aspects of knowledge work and on the nursing practice environment.

H_0: There will be no change in the nurses' perceptions of their ability to perform aspects of knowledge work or their nursing practice environment, measured by the I-HIT and EOM II respectively, from baseline (pre-implementation) to eight months post-implementation.

Nurse Perceptions of their Ability to Perform Aspects of Knowledge Work

Analysis for Differences in Mean Subscale Scores for the Paired Sample

To test the null hypothesis that there was no change in the nurse's perceptions of their ability to perform aspects of knowledge work from baseline (pre-implementation) to post-implementation, dependent sample *t*-tests were performed on each of the five I-HIT paired subscales. Prior to conducting the analysis, the assumption of normally distributed difference scores was examined for each subscale. The assumption was considered satisfied if the skew and kurtosis levels were less than the maximum allowable values for a *t*-test (i.e. skew < |2.0| and kurtosis < |9.0|) (Posten, 1984). All five I-HIT paired subscales satisfied the assumption of normally distributed difference scores with absolute skew values ranging from .067 to .60, and kurtosis ranging from .237 to 1.0. It should also be noted that the correlations between the pre- and post-implementation conditions ranged from $r = .287$ to .526, $p < .001$, suggesting that the dependent samples *t*-test is appropriate in this case.

Descriptive statistics associated with nurse perceptions of their ability to perform aspects of knowledge work, measured by pre-and-post implementation I-HIT subscale scores are reported in Table 4.5. The pre-implementation group was associated with satisfaction mean scores that ranged from $M = 3.99$ ($SD = 1.36$) *HIT Depersonalizes Care (HITDPC*) to $M = 4.60$ ($SD = .77$)

Information Tools to Support Communication Tasks (HITSCT). All five I-HIT subscales in the post-implementation group were associated with numerically lower mean subscale scores ranging from the lowest mean score *M = 3.40 (SD = 1.52)* in the *HITDPC* subscale to the highest mean score *M* = 4.36 (*SD* = .95) in the *HITSCT* subscale. *Workflow Implications of HIT* had the largest decrease in mean score, dropping .61 from pre- to post-implementation. In comparison, the mean score for *Information Tools to Support Communication Tasks* subscale decreased the least with a .24 decline. *HIT Depersonalizes Care* (*HITDPC*) subscale had the greatest variation in mean scores, and *Information Tools to Support Communication Tasks (HITSCT)* had the least variation across the pre- and post-implementation survey administrations.

Table 4.5

Descriptive Statistics for the Impact of Health Information Technology (I-HIT) Scale for the Paired Sample

			Pre-Implementation			Post-Implementation		
	Paired I-HIT Subscale Variables	*N*	*M*	*SD*	*SEM*	*M*	*SD*	*SEM*
Pair 1	General Advantages of HIT (HITGA)	434	4.25	.81	.04	3.66	1.15	.05
Pair 2	Workflow Implications of HIT (HITWF)	433	4.46	.84	.04	3.85	1.17	.06
Pair 3	Information Tools to Support Comm Tasks (HITSCT)	438	4.60	.77	.04	4.36	.95	.04
Pair 4	Information Tools to Support Info Tasks (HITSIT)	427	3.86	1.12	.05	3.52	1.24	.06
Pair 5	HIT Depersonalizes Care (HITDPC)	423	3.99	1.36	.06	3.40	1.52	.07

N = Sample
M = Mean
SD = Standard Deviation
SEM = Standard error of the mean

Across all five I-HIT subscales, paired sample t-tests indicated that the post-implementation mean scores were statistically significantly lower than the pre-implementation mean scores: *HITGA* $t(433) = 11.52$, $p < .001$; *HITWF* $t(432) = 12.34$, $p < .001$; *HITSCT* $t(437) = 5.69$, $p < .001$; *HITSIT* $t(426) = 6.14$, $p = < .001$; *HITDPC* $t(422) = 7.04$, $p < .001$. Therefore, the null hypothesis of no statistical change was rejected for all five I-HIT paired subscales. Table 4.6 presents results of the dependent samples *t*-tests for the I-HIT subscale variables. Based on

Cohen's guidelines (1992), effect sizes ranged from small, $d = 0.3$-0.4 for *HITSCT*, *HITSIT*, and *HITDPC* subscales, to moderate, $d = 0.6$ for *HITGA* and *HITWF* subscales.

Table 4.6

Paired Differences Test for the Impact of Health Information Technology (I-HIT) Scale

					95% CI				
	Paired I-HIT Subscale Variables*	*M*	*SD*	*SEM*	*CI LL*	*CI UL*	*t*	*df*	*Sig.*
Pair 1	General Advantages of HIT	.593	1.07	.052	.492	.695	11.52	433	.000
Pair 2	Workflow Implications of HIT	.614	1.04	.050	.516	.711	12.34	432	.000
Pair 3	Information Tools to Support Comm Tasks	.239	.880	.042	.157	.322	5.69	437	.000
Pair 4	Information Tools to Support Inform Tasks	.343	1.15	.055	.233	.452	6.14	426	.000
Pair 5	HIT Depersonalizes Care	.591	1.73	.084	.426	.756	7.04	422	.000

**HIT Subscale Phase 1-HIT Subscale Phase 2*

M = Mean

SD=Standard Deviation

SEM = Standard error of the mean

CI LL = Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

t = Paired Student's t distribution

df = Degrees of freedom

Sig. = $\alpha < .05$ (two-tailed test)

Analysis for Differences in Mean Subscale Scores for the Independent Sample

In the Independent sample, the null hypothesis of no change in the nurse's perceptions of their ability to perform knowledge work from baseline (pre-implementation) to post-implementation was tested by performing independent sample *t*-tests on each of the five I-HIT subscales. The pre- and post-implementation groups demonstrated acceptable levels of kurtosis with absolute values ranging from .51 to 5.48, below the acceptable level of |9|. With the exception of the *HIT Depersonalize*s *Care* subscale (a single-item measure), both the pre- and post-implementation groups demonstrated statistically significant levels of skewness for the other

four subscale variables (i.e. skew >|2|) (Schmider, Ziegler, Danay, & Beyer, 2010), therefore violating the assumption of sufficiently normal distributions for the purpose of conducting *t*-tests. Histograms of the pre- and post-implementation groups, demonstrated that, other than the skewness, distributions appeared otherwise normal. The Likert scale data used in this study are bounded by the nature of the six- and four-item response structure of the I-HIT and EOM II surveys respectively. However, the *t*-test is commonly used with Likert scale data and is robust at these levels of skewness and kurtosis (Cramer & Howitt, 2004). To ensure rigor, the Mann-Whitney *U* test was used to verify robustness of the parametric procedure.

Descriptive statistics associated with nurse perceptions of their ability to perform aspects of knowledge work for nurses in the independent sample are reported in Table 4.7. Across all five I-HIT subscales, the pre-implementation group was associated with numerically higher mean scores than the post-implementation group. The pre-implementation group was associated with satisfaction mean scores that ranged from $M = 3.82$ ($SD = 1.32$) HIT *Depersonalizes Care (HITDPC*) to $M = 4.42$ ($SD = .96$) *Information Tools to Support Communication Tasks (HITSCT).*These mean scores were consistent with the paired sample where *HITDPC* and *HITSCT* resulted in the low and high mean subscale scores respectively. All five I-HIT subscales in the post-implementation group were associated with numerically lower mean subscale scores ranging from the lowest mean score $M = 3.53$ *(*$SD = 1.31$*)* in the *Information Tools to Support Information Tasks (HITSIT)* subscale, to the highest mean score $M = 4.35$ ($SD = .97$) in the *Information Tools to Support Communication Tasks (HITSCT)* subscale. The *HITSIT* and *HITDPC* subscale means were within .04 of one another across both the independent sample groups, and were the two lowest mean subscale scores for both the paired and independent samples.

The G*eneral Advantages of HIT (HITGA)* subscale had the largest difference in mean scores, dropping .41 from pre- to post-implementation. In comparison, the mean score for

Information Tools to Support Communication Tasks (HITSCT) subscale remained virtually unchanged from the pre-implementation group, decreasing the least with a .07 decline. *Information Tools to Support Communication Tasks (HITSCT)* mean subscale scores were also the most stable for the paired sample. The *HITGA* subscale resulting in the largest decrease represents an inconsistency from the paired sample where the *HITWF* subscale resulted in the largest decrease. Although, it is notable that *HITWF* subscale decreased .36, the second largest decrease across the I-HIT subscales for the independent sample groups. Overall, the independent sample groups demonstrated smaller mean subscale decreases between pre- and post-implementation (range .07 *HITSCT* to .41 *HITGA*) when compared with the paired sample group (range .24 *HITSCT* to .61 *HITWF*). *HIT Depersonalizes Care* (*HITDPC*) subscale had the greatest variation in mean scores, which was consistent with the paired sample variance. However, *HITGA* had the least variation across the pre- and post-implementation survey administrations, which differed from the paired sample where *HITSCT* had the least variation.

Table 4.7

Descriptive Statistics: Two- Sample Independent t-Test for the I-HIT Scale

	Pre Intervention Only				Post Intervention Only			
I-HIT Subscale Variables	*N*	*M*	*SD*	*SEM*	*N*	*M*	*SD*	*SEM*
General Advantages of HIT	238	4.17	.95	.06	333	3.76	1.14	.06
Workflow Implications of HIT	240	4.40	.99	.06	332	4.04	1.22	.07
Information Tools to Support Comm Tasks	238	4.42	.96	.06	330	4.35	.97	.05
Information Tools to Support InfoTasks	235	3.83	1.25	.08	323	3.53	1.31	.07
HIT Depersonalizes Care	231	3.82	1.32	.09	328	3.57	1.52	.08

N = Sample

M = Mean

SD = Standard Deviation

SEM = Standard error of the mean

Results of the independent samples *t*-tests for the I-HIT subscale variables are presented in Table 4.8. Independent samples *t*-tests indicated that post-implementation mean scores were significantly lower than pre-implementation mean scores four subscales: *HITGA* $t(557) = 4.53$, $p < .001$; *HITWF* $t(562) = 3.80$, $p < .001$; *HITSIT* $t(555) = .903$, $p = .007$; and *HITDPC* $t(534) = 2.05$, $p = .041$. The assumption of homogeneity of variance was tested using the Levene's *F* test, but was not satisfied, indicating unequal variances for three subscales: *HITGA* ($F = 12.74$, $p < .001$); *HITWF* ($F = 10.73$, $p = .001$); and *HITDPC* ($F = 10.71$, $p = .001$). The degrees of freedom were adjusted for these three subscales: *HITGA* (from 569 *df* to 557 *df*); *HITWF* (from 570 *df* to 562 *df*); *HITDPC* (from 557 *df* to 534 *df*). Effect sizes ranged from small, $d = 0.2$-0.3 for *HITWF*, *HITSIT*, and *HITDPC*, to moderate, $d = 0.4$ for *HITGA*. The Mann-Whitney *U* mirrored the results yielded from the parametric *t*-tests for the subscales with statistically significant skewness: *HITGA* ($U = 32{,}249$, $p < .001$, $r = .2$); *HITWF* ($U = 33{,}462$, $p = .001$, $r = .1$); *HITSIT* ($U = 32{,}668$, $p = .006$, $r = .1$). Since the post-implementation mean scores for these I-HIT subscales were statistically lower than the pre-implementation mean scores, the null hypothesis was rejected.

The post-implementation mean *Information Tools to Support Communication Tasks (HITSCT)* subscale score was not statistically significant different from the pre-implementation scores, $t(566) = .903$, $p = .367$; $U = 36{,}770$, $p = .194$), therefore, the null hypothesis was accepted.

Table 4.8

Two-Sample Independent t-Test for the I-HIT Scale

	t-test for Equality of Means						
I-HIT Subscale Variables	*t*	*df*	*Sig.*	*M*	*SE*	*CI LL*	*CI UL*
General Advantages of HIT	4.53	557	.000	.398	.088	.225	.570
Workflow Implications of HIT	3.80	562	.000	.353	.093	.171	.535
Information Tools to Support Comm Tasks	.903	566	.367	.074	.082	-.087	.235
Information Tools to Support Info Tasks	2.70	555	.007	.296	.110	.081	.511
HIT Depersonalizes Care	2.05	534	.041	.248	.121	.011	.485

t = Paired Student's *t* distribution

df = Degrees of freedom

Sig. = $\alpha < .05$ (two-tailed test)

M = Mean

SE= Standard error

CI LL = Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Nurses' Perceptions of the Effect of the CDSS Implementation on the Nursing Practice Environment

Essentials of Magnetism (EOM II) Instrument Description

The *Essentials of Magnetism II (EOM II)* was used to assess nurses' perceptions about their practice environment, before and after the implementation of the CDSS. The subscales emphasize aspects of the environment and practice that are essential to the performance of knowledge work, including: clinical autonomous decision-making, nurse-physician relationships that are collegial and collaborative, a culture that focuses on patient safety and quality of care delivery, and organizational support for nurse-led care problem-solving and innovation.

EOM II Item Descriptive Statistics: Pre-and-Post Implementation Mean Difference Scores

Mean difference scores for pre- and post-implementation EOM II items are included in Appendix J Tables 4.1 and 4.2 for the paired and independent samples respectively. The majority of EOM II questions, (88%) for the paired sample and (95%) for the independent sample, showed an increased level of satisfaction. In both cases, however, the increased level of satisfaction was small. Only 25% of the independent survey increases exceeded .10. This trend was even more pronounced with paired sample, where only 19.7% of the increases exceeded .10. Only one EOM II item for either the paired or independent sample reached a mean score increase of .19; Item 5 for the paired sample survey, "*Our nurse-physician relationships are rather formal and characterized mainly by the nurse responding to the physician's questions*" resulted in this increase. In fact, only 10 items across both samples had increased mean scores equal to or greater than 0.15; 6.7% of paired sample items (questions 5, 7, 21, and 22), and 10.1% of independent sample items (questions 3, 10, 17, 27, 35, and 50) yielded this level of increased satisfaction.

Six independent and two paired sample survey questions recorded a decline in satisfaction. All of these changes were at or below .07. The only two independent sample

decreases were at or below .01. Overall, the analysis of the EOM II item mean difference scores demonstrated that the number of questions recording increased satisfaction was quite high, but the differences in the means showed almost no change, which is indicative that nurse perceptions of their practice environment remained stable.

Analysis for Differences in Mean Subscale Scores for the Paired Sample

To test the null hypothesis that there was no change in the nurse's perception of the nursing practice work environment baseline (pre-implementation) to post-implementation, dependent sample *t*-tests were performed on each of the EOM II paired subscales. Prior to conducting the analysis, the assumption of normally distributed difference scores was examined for each subscale. The assumption was considered satisfied if the skewness and kurtosis levels were less than the maximum allowable values for a *t*-test (i.e. skew < |2.0| and kurtosis < |9.0|) (Posten, 1984). All EOM II paired subscales satisfied the assumption of normally distributed difference scores with absolute values ranging from .011 to .307. Kurtosis absolute values ranged from .228 to 2.64. It should also be noted that the correlations between the pre- and post-implementation conditions ranged from $r = .505$ to .708 ($p < .001$); suggesting that the dependent samples *t*-test is appropriate in this case.

Descriptive statistics associated with nurse perceptions of their practice environment, measured by pre- and -post implementation EOM II subscale scores are reported in Table 4.9. The pre-implementation group was associated with satisfaction scores that ranged from $M = 8.37$ ($SD = 1.29$) *Nurse-Assessed Quality of Patient Care on Unit (QoC*) to $M = 314.3$ ($SD = 37.2$) *Professional Practice Satisfaction / Total EOM II (PPS*). *QoC* is a single item subscale where nurses are asked to rate the usual quality of care delivered on the patient care unit using a scale from 0 to 10. The *PPS* subscale is the sum of all EOM II items. All ten EOM II subscales in the post-implementation group were associated with numerically higher mean subscale scores

ranging from the lowest mean score *M = 8.42 (SD* = 1.21*)* in the *QoC* subscale to the highest mean score *M* = 322 (*SD* = 38.2) in the *PPS* subscale. *Professional Practice Satisfaction* and *Control Over Nursing Practice* (*CNP*) had the largest increase in mean scores, increasing 7.7 and 3.04 from pre- to post-implementation respectively. *Clinical Autonomy* had the next largest with an increase of 2.18 from pre- to post-implementation. In comparison, the mean score for the single-item *QoC* subscale improved the least, remaining nearly unchanged, with a .05 increase. Nurses' perceptions of *Working with Clinically Competent Peers* (*CCP*) also remained nearly unchanged, increasing only .15 from pre- to post-implementation. Subscales that had the greatest variation in mean scores were *Professional Practice Satisfaction* (*PPS*), *Control Over Nursing Practice* (*CNP*), and *Clinical Autonomy* (*AUTO*). *Nurse-Assessed Quality of Patient Care on Unit (QoC), Working with Clinically Competent Peers (CCP), and Support for Education (SuppED)* had the least variation across the pre- and post-implementation survey administrations.

Table 4.9

Descriptive Statistics of Essentials of Magnetism II (EOM II) for the Paired Sample

			Pre-Implementation			Post-Implementation		
	Paired EOM II Subscale Variables	*N*	*M*	*SD*	*SEM*	*M*	*SD*	*SEM*
Pair 1	Nurse-Physician Relationships	458	46.24	7.40	.34	47.06	8.08	.38
Pair 2	Support for Education	458	12.11	1.72	.08	12.41	1.84	.09
Pair 3	Clinical Autonomy	458	79.41	11.8	.55	81.59	11.7	.55
Pair 4	Control over Nursing Practice	457	76.58	11.9	.56	79.62	12.0	.56
Pair 5	Perceived Adequacy of Staffing	458	17.52	2.81	.13	17.76	2.71	.13
Pair 6	Working with Clinically Competent Peers	458	12.50	1.83	.09	12.65	1.81	.08
Pair 7	Nurse Manager Support Index	458	36.48	6.54	.31	36.97	6.76	.32
Pair 8	Patient-Centered Cultural Values	458	33.60	4.51	.21	34.02	4.48	.21
Pair 9	Professional Practice Satisfaction	458	314.3	37.2	1.8	322.0	38.2	1.8
	Single-Item Outcome Indicator Variable							
Pair 10	Nurse-Assessed Quality of Patient Care on Unit	453	8.37	1.29	.06	8.42	1.21	.06

N=Sample

M = Mean

SD=Standard Deviation

SEM= Standard error of the mean

In five of the ten EOM II subscales, paired sample *t*-tests indicated that the post-implementation mean subscale scores were statistically significantly higher than the pre-implementation mean scores: *Nurse Physician Relationships* (*RNMD*) $t(457) = -2.51$, $p = .012$; *Support for Education* (*SuppED*) $t(457) = -3.65$, $p < .001$; *Clinical Autonomy* (*AUTO*) $t(456) = -4.51$, $p < .001$; *Control Over Nursing Practice* (*CNP*) $t(453) = -5.58$, $p < .001$; and *Professional Practice Satisfaction* (*PPS*) $t(452) = -5.73$, $p < .001$. Since multiple comparisons were required for the ten EOM II subscales, a Bonferroni procedure was used to correct for multiple comparisons and family-wise type 1 error rate. Comparisons were considered significant if was $p \leq 0.125$ (Howell, 2002; Munro, 2005). Table 4.10 presents results of the dependent samples *t*-tests for the EOM II subscale variables. Effect sizes ranged from very small, $d = 0.1$ for *RNMD*, to small, $d = 0.2$-0.3 for *SuppED, AUTO*, *PPS*, and *CNP*.

The mean differences scores for subscales *Perceived Adequacy of Staffing* (*STAFF*), *Manager Support Index (NMS), Working with Clinically Competent Peers (CCP), Patient-Centered Values (PCV), and Nurse-Assessed Quality of Patient Care on Unit (QoC)* were not statistically significantly higher and, therefore the null hypothesis of equal means was accepted.

Table 4.10

Test of Paired Differences for the Essentials of Magnetism II (EOM II)

					95% CI				
	Paired EOM II Subscale Variables*	*M*	*SD*	*SEM*	*CI LL*	*CI UL*	*t*	*df*	*Sig.*
Pair 1	Nurse-Physician Relationships	-.820	6.98	.33	-1.46	-.178	-2.51	457	.012
Pair 2	Support for Education	-.300	1.78	.08	-.467	-.140	-3.65	457	.000
Pair 3	Clinical Autonomy	-2.20	10.45	.48	-3.14	-1.23	-4.51	456	.000
Pair 4	Control over Nursing Practice	-3.00	11.61	.54	-4.11	-1.97	-5.58	453	.000
Pair 5	Perceived Adequacy of Staffing	-.240	2.42	.11	-.468	-.022	-2.16	452	.031
Pair 6	Working wth Clinically Competent Peers	-.150	1.67	.08	-.306	.002	-1.95	452	.052
Pair 7	Nurse Manager Support Index	-.490	5.55	.26	-1.01	.018	-1.98	452	.058
Pair 8	Patient-Centered Cultural Values	-.410	3.90	.18	-.775	-.053	-2.25	451	.025
Pair 9	Professional Practice Satisfaction	-7.80	28.8	1.4	-10.4	-5.10	-5.73	452	.000
	Single-Item Outcome Indicator Variable								
Pair 10	Nurse-Assessed Quality of Patient Care	.06	1.12	.05	-.161	.046	1.09	452	.276

**EOM Subscale Phase 1 – EOM Subscale Phase 2*

M = Mean

SD=Standard Deviation

SEM= Standard error of the mean

CI LL = Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

t = Paired Student's t distribution

df = Degrees of freedom

Sig. = $\alpha < .0125$ (two-tailed test)

Analysis for Differences in Mean Subscale Scores for the Independent Sample

To test the null hypothesis that there was no difference in nurse's perception of the nursing practice work environment baseline (pre-implementation) to post-implementation,

independent sample *t*-tests were performed on each of the EOM II subscales. The pre- and post-implementation groups demonstrated acceptable levels of kurtosis (i.e. kurtosis < |9|).

With the exception of two pre-implementation subscales (*Support for Education and Patient-Centered Values*) and four post-implementation subscales (*Control Over Nursing Practice, Working with Clinically Competent Peers, Patient-Centered Values, and Professional Practice Satisfaction*), all other subscale variables demonstrated statistically significant levels of skewness (i.e. skew |2|) (Schmider et al., 2010), and violate the assumption of sufficiently normal distributions for the purpose of conducting *t*-tests. Histograms of the pre- and post-implementation groups demonstrated that, other than the skewness, distributions appear otherwise normal. The Likert scale data used in this study are bounded by the nature of the six- and four-item response structure of the I-HIT and EOM II surveys respectively. However, the *t*-test is commonly used with scale data and is robust at these levels of skew and kurtosis (Cramer & Howitt, 2004). To ensure rigor, Mann-Whitney *U* tests were performed, and the results were replicated for levels of significance.

Descriptive statistics for the independent sample pre- and post-implementation EOM II subscale scores are reported in Table 4.11. The pre-implementation group was associated with satisfaction scores that ranged from $M = 8.43$ ($SD = 1.30$) for *QoC* to $M = 316$ ($SD = 36.9$) for *PPS.* All ten EOM II subscales in the post-implementation independent group, demonstrated numerically higher mean subscale scores ranging from the lowest mean score *M = 8.50 (SD = 1.30)* in the *QoC* subscale to the highest mean score $M = 322.7$ ($SD = 38.2$) in the *PPS* subscale; these subscale scores were consistent with the results from the EOM II paired sample.

Consistent with the paired EOM II sample results, *PPS* and *CNP* also had the largest increase in mean scores, increasing 6.5 and 2.61 from pre- to post-implementation respectively in the independent sample. Similarly, *AUTO* had the next largest increase of 1.68 from pre- to post-implementation. The mean score for the single-item *QoC* subscale improved the least with a .07

increase; this result was consistent with the paired sample .05 increases. However, unlike the paired sample where *CCP* remained nearly unchanged, in the independent sample *CCP* had a greater mean subscale score increase of .39. Instead, *RNMD* in the independent sample increased by only .11, remaining relatively constant, as compared with the paired sample where it increased by .82.

Subscales that had the greatest variation in mean scores were *PPS*, *AUTO, and CNP*. Nurse-Assessed Quality of Patient Care on Unit *(QoC), SuppED*, and *CCP* had the least variation across the pre- and post-implementation survey administrations.

Table 4.11

Descriptive Statistics of Essentials of Magnetism II for the Independent Sample

	Pre Intervention Only				Post Intervention Only			
EOM II Subscale Variables	*N*	*M*	*SD*	*SEM*	*N*	*M*	*SD*	*SEM*
Nurse-Physician Relationships	252	46.19	8.52	.536	331	46.30	8.04	.442
Support for Education	251	12.07	1.73	.109	331	12.36	1.67	.092
Clinical Autonomy	250	80.10	11.2	.711	331	81.78	11.70	.643
Control over Nursing Practice	250	77.60	11.2	.712	328	80.21	11.44	.632
Perceived Adequacy of Staffing	250	17.59	2.62	.165	329	17.85	2.75	.152
Working with Clinically Competent Peers	250	12.46	1.71	.108	329	12.85	1.78	.098
Nurse Manager Support Index	250	36.75	6.28	.397	330	37.16	6.66	.366
Patient-Centered Cultural Values	250	33.50	4.61	.291	329	34.32	4.80	.265
Professional Practice Satisfaction	250	316.2	36.9	2.33	328	322.7	38.25	2.11
Single-Item Outcome Indicator Variable								
Nurse-Assessed Quality of Patient Care	251	8.43	1.30	.082	328	8.50	1.30	.072

N=Sample

M = Mean

SD=Standard Deviation

SEM= Standard error of the mean

The post-implementation EOM II mean subscale sores were statistically significantly higher than the pre-implementation mean scores for two of the ten EOM II subscales: *CNP* $t(576) = -2.74$, $p = .006$; *CCP* $t(577) = -2.65$, $p = .008$. The assumption of homogeneity of variance was

tested and satisfied with the Levene's *F* test. The Bonferroni procedure was used to correct for multiple comparisons and family-wise type 1 error rate. Comparisons were considered significant if was $p \leq 0.125$ (Howell, 2002; Munro, 2005).The null hypothesis of equal means was rejected for these two subscales and the alternate hypothesis accepted. Effect sizes ranged from very small, $d = 0.1$ for *CCP,* to small, $d = 0.3$ for *CNP.* The Mann-Whitney *U* mirrored the results of the parametric *t*-tests, finding the same two subscales statistically significant: *CNP* ($U = 36{,}953$, $p < .009$, $r = .1$); *CCP* ($U = 37{,}218$, $p = .011$, $r = .1$). The mean scores for the remaining eight subscales were not significantly different from zero, and the null hypothesis was accepted.

Notably, fewer statistically significant EOM II subscale differences were found in the independent sample than in the paired sample, where five of the 10 subscales were found to have significant differences between the pre- and post-implementation surveys. *Control Over Nursing Practice* (*CNP*) was the only subscale found to have statistically significant differences in both the paired and independent samples. *Working with Clinically Competent Staff* (*CCP*) was found to be significant in the independent, but not the paired sample. *Nurse Perceptions of Adequate staffing* (*STAFF*), *Nurse Manager Support Index* (*NMS*), *Patient-Centered Values* (*PCV*), and *Nurse-Assessed Quality of Patient Care on Unit* (*QoC*) were not significant in either sample.

Table 4.12

Two-Samples Independent t-Test of Essentials of Magnetism II (EOM II)

	t-test for Equality of Means						
EOM II Subscale Variables	*t*	*df*	*Sig.*	*M*	*SE*	*CI LL*	*CI UL*
Nurse-Physician Relationships	-.300	581	.764	-.207	.690	-1.56	1.15
Support for Education	-2.00	580	.045	-.285	.142	-.564	-.006
Clinical Autonomy	-1.74	579	.083	-1.67	.964	-3.57	.218
Control over Nursing Practice	-2.74	576	.006	-2.61	.954	-4.48	-.737
Perceived Adequacy of Staffing	-1.17	577	.240	-.266	.226	-.710	.178
Working with Clinically Competent Peers	-2.65	577	.008	-.390	.147	-.679	-.101
Nurse Manager Support Index	-.756	578	.450	-.412	.545	-1.48	.658
Patient-Centered Cultural Values	-2.05	577	.041	-.812	.396	-1.59	-.034
Professional Practice Satisfaction	-2.05	576	.040	-6.50	3.16	-12.7	-.287
Single-Item Outcome Indicator Variable	*t*	*df*	*Sig.*	*M*	*SE*	*CI LL*	*CI UL*
Nurse-Assessed Quality of Patient Care	-.556	577	.579	-.060	.109	-.275	.153

t = Paired Student's t distribution

df = Degrees of freedom

Sig. = $\alpha < .0125$ (two-tailed test)

M = Mean

SE= Standard error

CI LL = Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

EOM II Subscale Intercorrelations

The EOM II demonstrated generally more moderate subscale intercorrelations than the I-HIT, with Pearson's coefficient values across the both the pre- and post-implementation samples, ranging from $r = .221$ ($p = < .001$) between *QoC* and *SuppED* in the independent sample, to $r = .885$ ($p = < .001$) between the paired sample *AUTO* and *PPS* subscales.

Professional Practice Satisfaction (Total EOM II) demonstrated moderate to very high correlation with the other nine EOM II subscales across both the paired and independent samples. Pearson's correlation coefficients ranged from $r = .556$ ($p < .001$) for *RNMD*, to $r = .896$ ($p < .001$) for *AUTO*. This result is expected since the *PPS* subscale is the total of all the other EOM II subscales. However, it is notable that both the *Clinical Autonomy* (*AUTO*) and *Control Over Nursing Practice* (*CNP*) subscales were highly correlated with PPS for both the paired and independent samples and across both the pre- and post-implementation phases. Pearson's correlation coefficients for these two subscales ranged from $r = .829$ ($p < .001$) to $r = .896$ ($p < .001$). This demonstrates that these two concepts, hallmarks of nurse knowledge work, are important drivers of overall nurse satisfaction with their professional practice. Appendix K Tables 4.1 through 4.4 provides the Pearson's subscale intercorrelations.

Essentials of Magnetism II Reliability Analysis

Internal consistency using Cronbach's alpha was assessed for the three sample groups: Paired, pre-implementation, and post-implementation. Cronbach alphas consistent with the published psychometrics (Schmalenberg & Kramer, 2008), are shown in Appendix L Tables 4.1 through 4.3. The paired sample group had an overall Cronbach's alpha of .951. The Cronbach *Alpha if Item Deleted* values ranged from .949 to .951 indicating that all questions contributed and none should be dropped. The pre-implementation sample group had an overall Cronbach's alpha of .949. The *Cronbach Alpha if Item Deleted* values were consistently between .947 - .950

showing excellent internal consistency across all question items. Similarly, the post-implementation sample had an overall Cronbach's alpha of.953 and *Cronbach Alpha if Item Deleted* values ranging between .951 and .954.

Summary of Specific Aim 1

Overall Results

- Response rates for both pre and post-implementation phases approximately 50% or greater—yielding > 700 cases in each study phase.
- The Registered Nurse participants are on average, well-educated (bachelor's degree or higher) and younger than national benchmarks. Minorities are represented in the sample at 2010 HHS national benchmark levels or above.
- Registered nurse participants work in a representative distribution of clinical unit types across the organization.
- Replication of the I-HIT psychometric evaluation yielded a five factor structure, which differed from the four component structure in the original psychometrics.

Aim 1: Nurse Perceptions of their Ability to Perform Aspects of Knowledge Work

Impact of Health Information Technology (I-HIT)

- All five I-HIT mean subscale scores decreased post-implementation, for both the paired and independent samples. This equates to decreased perceptions of satisfaction about nurses' ability to perform aspects of knowledge work.
- Of the combined paired and independent subscales the decrease was statistically significant for all but one subscale. These results are summarized in Table 4.13.
- Effect sizes ranged from 0.1 to 0.6 and were generally larger in the paired sample. These results are summarized in Table 4.14.
- Information tools to support communication tasks had the highest post-implementation mean subscale score ($M = 4.36$). The post implementation *HIT Depersonalizes Care* had the lowest score of any subscale ($M = 3.40$).

- Subscales with the largest decrease, pre and-post implementation, were *General Advantages of HIT*, *HIT Depersonalizes Care*, and *Workflow Implications of HIT*, with decreases ranging from .59 to .61.

Table 4.13

Comparison of I-HIT Paired and Independent Sample Mean Subscale Differences

	IHIT Subscales	Paired *t*-test Sig. .05 = X	Independent *t*-test Sig. .05 = X
1	General Advantages of HIT	X	X
2	Workflow Implications of HIT	X	X
3	Information Tools to Support Communication Tasks	X	
4	Information Tools to Support Information Tasks	X	X
5	HIT Depersonalizes Care	X	X

Table 4.14

Effect Size for I-HIT Paired and Independent Samples t-tests

	I-HIT Subscale	Cohen's *d*	
		Paired	Independent
1	General Advantages of HIT	0.6	0.4
2	Workflow Implications of HIT	0.6	0.3
3	Information Tools to Support Communication Tasks	0.3	
4	Information Tools to Support Information Tasks	0.3	0.2
5	HIT Depersonalizes Care	0.4	0.2

Aim 1: Nurses' Perceptions of their Nursing Practice Work Environment

Summary of Results for Essentials of Magnetism (EOM II)

- All EOM II post implementation subscales increased numerically, equating to increased satisfaction with the practice environment, for both the paired and independent samples.
- Five of the paired subscales and two of the independent subscales had statistically significant post implementation increases. These results are summarized in Table 4.15.
- The effect sizes ranged from 0.1 to 0.3 equating to extremely small (effectively unchanged) to small increases in satisfaction with the practice environment. These results are summarized in Table 4.16.
- EOM item pre- and post-implementation mean difference scores showed little variation, with average scores increasing 0.1—effectively unchanged.

Table 4.15

Comparison of EOM II Paired and Independent Sample Mean Subscale Differences

	EOM II	Paired *t* test Sig .0125 = X	Independent *t* test Sig .0125 = X
1	Nurse Physician Relationships	X	
2	Support for Education	X	
3	Clinical Autonomy	X	
4	Control Over Nursing Practice	X	X
5	Perceived Adequacy of Staffing		
6	Working with Clinically Competent Peers		X
7	Nurse Manager Support Index		
8	Patient-Centered Values		
9	Professional Practice Satisfaction (Total EOM II)	X	
10	Nurse-Assessed Quality of Patient Care on Unit		

Table 4.16

Effect Size for EOM II Paired and Independent Samples t-tests

	EOM II Subscale	Cohen's *d*	
		Paired	Independent
1	Nurse-Physician Relationships	0.1	
2	Support for Education	0.2	
3	Clinical Autonomy	0.2	
4	Control Over Nursing Practice	0.3	0.3
5	Perceived Adequacy of Staffing		
6	Working with Clinically Competent Peers		0.1
7	Nurse Manager Support Index		
8	Patient-Centered Values		
9	Professional Practice Satisfaction (Total EOM II)	0.2	
10	Nurse-Assessed Quality of Patient Care on Unit		

Specific Aim 2

Aim 2: Examine a set of nurse and patient care unit characteristic variables and their corresponding explained variance associated with nurses' perceptions of their ability to perform aspects of knowledge work and the nursing practice environment (measured by each I-HIT and EOM II subscale).

Potentially Confounding Operational Variable Analysis

Two variables, Direct Care Hours Per Patient Day (DCHPPD), a standard measure of nurse staffing, and nurse turnover were examined as potential confounders that might influence nurses' perceptions of their ability to perform aspects of knowledge work and about their practice environment. Increased turnover and decreased DCHPPD would be expected to generally diminish morale and complicate the transition to a new CDSS. An analysis was performed to determine if either variable needed to be included in the regression model: to assess whether these variables were significant predictors of nurse satisfaction, and to determine the amount of variance accounted for by these variables on nurse-reported outcomes. However, trends in DCHPPD and nurse turnover rates demonstrated that these potential predictor variables were relatively stable over the 6 months prior to implementation and during the 8 months post-implementation. The DCHPPD and turnover variables showed weak correlations at months 6 and 14 (June and February) when the pre- and post-implementation surveys were administered. Some correlation between turnover rates and perceptions of staffing is expected, as turnover is often a leading indicator of staffing shortages when departing employees are not proactively replaced. In this case the weak correlations were not operationally meaningful. Appendix M Tables 4.1 through 4.3 provides the trend analysis and correlation coefficients for the DCHPPD and nurse turnover.

Regression Analysis

Thirteen nurse and unit characteristic independent variables were analyzed individually in simple bivariate regression models with the I-HIT and EOM dependent outcome subscale variables. Variables found to be significant at the 0.2 level or below were retained for further analysis in sequential backward elimination as described in the analysis plan specified in *Chapter 3: Study Design and Methods*.

Two variables, *Total Years Experience* and *Years HUP Tenure* were tested in simple models as both a continuous and categorical variable. Whenever the continuous and categorical variables were both significant at the 0.2 level, the variable with an accompanying significant interaction (variable*time or variable*group) was included for consideration in the final model. In cases where neither the continuous, nor the categorical variable had an interaction variable equal to or less than 0.2, then the variable with the most significant *p* value was selected. Both variable types were not included to prevent collinearity.

Pearson's correlation coefficients between independent variables demonstrated potential collinearity for the following variables: *Total Years Experience*, *Years HUP Tenure*, and *Age* with coefficients ranging from $r = .717$ to .866 ($p < .001$). *Clinical Ladder*, *Total Years Experience* and *Years HUP Tenure* were also correlated, but not as strongly, with coefficients ranging from $r = .5$ to .6 ($p = < .001$) on average, across all I-HIT and EOM subscales.

After testing in simple regression models, each of the 13 independent variables equal to or less than 0.2 were entered into repeated measures general linear models (GLM) for the paired sample, and univariate general linear models (GLM) for the independent sample.

For the paired sample, "Time" was identified as the within-subjects factor name that specified the two levels of comparison for each pre- and -post subscale dependent outcome variable in each of the 15 repeated measure GLM models (5 I-HIT, 10 EOM II). "Group" was entered as a fixed factor variable in each of the 15 univariate GLM models to specify the pre-

from the post-implementation cases: Group 1 = pre-implementation and Group 2 = post-implementation. Like "Time" in the repeated measures models, "Group" connoted the two distinct measurement points before and after CDSS implementation.

Backward manual elimination was conducted until the variables remained significant at the 0.10 level or less. The 0.10 level was recommended by a professional statistician and the dissertation committee, and reflects the exploratory nature of the study (Maldonado & Greenland, 1993; Vittinghoff, Glidden, Shiboski, & McCulloch, 2005). Appendix N Tables 4.1 and 4.2 outline the independent variables eliminated from each of the 30 models, sequentially, based on least significance.

A total of 26 candidate variables, 13 main-effect and 13 interaction, were evaluated and included in final models, on the basis of significance, for each of the 30 regression models. Post hoc analysis with Sidak adjustments were performed on all categorical independent variables comprised of greater than two levels. The assumption of homoscedasticity was met in all final regression models, as assessed by visual inspection of plots of standardized residuals versus unstandardized predicted values. The assumption of normality was met for all models, as assessed by Q-Q plots of residuals.

In order to address Specific Aim 2, repeated measure and univariate GLM regression models were performed on all 30 subscale outcome variables (10 I-HIT and 20 EOM II). Results for all 30 regression models are summarized in Tables 4.17 through 4.28. However, the following sections selectively present regression procedure results for the 16 subscale outcome variables (nine I-HIT and seven EOM II) found significant in the paired and independent samples *t*-tests that were performed in the Specific Aim 1 analysis.

Repeated Measures GLM Models for I-HIT for the Paired Sample

Table 4.17 provides results for all final I-HIT paired sample GLM regression models. Estimated marginal means and pairwise comparisons for the I-HIT paired sample are presented in Table 4.18. Parameter estimates for continuous independent variables included in final I-HIT paired sample regression models are summarized in Table 4.19.

Repeated Measures (RM) GLM showed main-effects of *Education outside the USA* (*EDOUT*) $F(1, 391) = 4.37$, $p = .037$; *Clinical Unit Type (CU)* $F(5, 391) = 4.93$, $p < .001$; and *Race* $F(2, 391) = 6.44$, $p = .002$ on nurse perceptions of the *General Advantages of HIT* (*HITGA).* Post hoc comparisons demonstrated that nurses educated outside the USA held more favorable views of *HITGA* than those educated domestically. Nurses working in Intensive Care (ICU) and Women's Health (WH) units held the least favorable views and demonstrated a significant decrease in satisfaction post CDSS implementation. Perceptions of *HITGA* demonstrated significant differences among years of *Years HUP Tenure (HUPTEN)* $F(6,391) = 2.42$, $p = .026$, and across time *HUPTEN* $F(6, 391) = 9.53$, $p = .066$, with nurses with < 3 years tenure and those with 20^{+} to 30 years decreasing from pre- to post-implementation. Nurses with 5^{+} to 10 years viewed the system more favorably post-implementation. Employment status also predicted views of *HITGA.* Working a greater number of hours per pay period *(HrsPP)* predicted slightly higher *HITGA* subscale means (B =.006, $p = .032$). Nurses of White race ($M = 3.90$) reported lower perceived satisfaction with *HITGA* than Asian/Pacific Islander ($M = 4.37$).

Repeated Measures GLM showed that four main-effect and two interaction variables predicted the variance in *Workflow Implications of HIT* (*HITWF*). Consistent with *HITGA*, nurses educated outside the USA held more favorable perceptions of *HITWF*, $F(1, 397) = 3.88$, $p = .050$. *CU* predicted decreases in mean scores across time for all unit types; nurses working in ICUs held the least favorable views ($M = 4.26$, $p = .014$). A significant difference was demonstrated among nurses of different C*linical Ladder* levels (*CLADD*) $F(2, 397)$, $p = .005$, with novice nurses

holding the most favorable views ($M = 4.75$) in comparison with expert nurses who scored the lowest ($M = 4.33$). Also consistent with *HITGA*, White nurses held the least favorable views ($M = 4.19$) in comparison with Asians who were the most satisfied ($M = 4.81$), with both racial groups decreasing in mean scores from pre- to post-implementation.

Information Tools to Support Communication Tasks (HITSCT) showed significant main-effects for *Education Outside the USA (EDOUT)* $F(1,393) = 7.66$, $p = .050$; *HUPTEN* $F(6, 393) = .16$, $p = .046$, *CU*Time* $F(5, 393) = 3.20$, $p = .008$; *Race* $F(2, 393) = 5.87$, $p = .003$; *Shift* $F(2, 397) = 4.07$, $p = .018$; and *HrsPP* $F(1, 393) = 3.33$, $p = .069$. Like *HITGA* and *HITWF,* being educated outside the USA predicted higher perceived satisfaction, as did working in an ICU ($M = 4.50$), in comparison with those working in a Medical or WH unit, who scored the highest. As in previous the model results, ICU nurses also continued to demonstrate lower mean satisfaction scores post CDSS implementation. White nurses continued to be the least satisfied ($M = 3.71$) in comparison to Asians who were the most satisfied ($M = 4.40$). Working day shift predicted higher mean satisfaction in comparison to those working nights for *HITSCT.* However, satisfaction for those who worked night shift did improve post CDSS implementation. Employment status was also consistent with *HITGA* with *HrsPP* demonstrating a small increase mean satisfaction over time and with increased hours worked per pay.

The *Information Tools to Support Information Tasks (HITSIT)* variance was explained by very similar main-effect and interaction variables as *HITSCT*, with *EDOUT* $F(1, 389) = 3.92$, $p = .051$; *CU*Time* $F(5, 389) = 6.67$, $p < .001$; and *Race* $F(2, 389) = 12.1$, $p < .001$. Post hoc comparisons were consistent with the other I-HIT subscale outcomes with internationally educated nurses enjoying greater satisfaction, and Whites and ICU nurses reporting less than their counterparts.

HIT Depersonalizes Care (*HITDPC*) was not consistent with the other I-HIT subscale outcomes. In addition to main-effect and interaction variables *CU*Time F*(5, 389) = 2.52, *p* = .029; and *HrsPP*Time F*(1, 389) = 6.95, *p* = .009; and *Race F(*2, 389) = 3.87*, p* = .022*, HITDPC* was explained by *Ethnicity* and *Ethnicity*Time*, with Non-Hispanics or Latinos reporting lower mean scores, and their satisfaction also decreased over time post CDSS implementation. Notably, Asians (*M* = 3.56) were less satisfied than Whites (*M* = 4.04) or Blacks (*M* = 4.19), which was also a departure from other I-HIT subscale outcomes.

Table 4.17

Final Repeated Measures GLM Model Summary for I-HIT

Paired Sample

	Sum of Squares	Mean Square	*df*	*F*	*p**	Partial Eta Squared
1) *General Advantages of HIT (HITGA)*						
Education Outside of USA	5.42	5.42	1	4.37	.037	.011
Years HUP Tenure_Coded	18.0	3.00	6	2.42	.026	.036
Years HUP Tenure_Coded*Time	5.84	0.97	6	1.99	.066	.030
Clinical Unit Type	30.5	6.11	5	4.93	<.001	.059
Clinical Unit Type*Time	23.3	4.67	5	9.53	<.001	.109
Race	15.9	7.98	2	6.44	.002	.032
Hours per pay period*Time	2.08	2.08	1	4.25	.040	.011
Error	484	1.24	391			
2) *Workflow Implications of HIT (HITWF)*						
Education Outside of USA	5.22	5.22	1	3.88	.050	.010
Clinical Ladder	14.7	7.37	2	5.47	.005	.027
Clinical Unit Type	19.5	3.90	5	2.89	.014	.035
Clinical Unit Type*Time	20.7	4.15	5	8.76	<.001	.099
Race	30.0	15.0	2	11.2	<.001	.053
Race*Time	3.44	1.72	2	3.62	.028	.018
Error	188	.474	397			
3) *Information Tools to Support Communication Tasks (HITSCT)*						
Education Outside of USA	7.63	7.63	1	7.66	.006	.019
Years HUP Tenure_Coded*Time	4.73	0.79	6	2.16	.046	.032
Shift	8.10	4.05	2	4.07	.018	.020
Shift*Time	1.98	0.99	2	2.71	.068	.014

Clinical Unit Type	12.6	2.51	5	2.52	.029	.031
Clinical Unit Type*Time	5.83	1.17	5	3.20	.008	.039
Race	11.7	5.84	2	5.87	.003	.029
Race*Time	2.16	1.08	2	2.97	.053	.015
Hours per pay period	3.32	3.32	1	3.33	.069	.008
Error	391	.996	393			
4) *Information Tools to Support Information Tasks (HITSIT)*						
Education Outside of USA	10.9	10.9	1	5.83	.016	.015
Total Years Experience_Coded	23.8	3.96	6	2.11	.051	.032
Clinical Unit Type*Time	20.2	4.05	5	6.67	<.001	.079
Race	45.5	22.8	2	12.1	<.001	.059
Error	236	.607	389			
5) *HIT Depersonalizes Care (HITDPC)*						
Clinical Unit Type*Time	17.5	3.51	5	2.53	.029	.032
Ethnicity	7.31	7.31	1	2.86	.091	.007
Ethnicity*Time	6.53	6.53	1	4.70	.031	.012
Race	19.8	9.88	2	3.87	.022	.020
Race*Time	11.6	5.78	2	4.17	.016	.021
Hours per pay period*Time	9.64	9.64	1	6.95	.009	.018
Error	985	2.55	389			

df = Degrees of freedom

F = F distribution

p = Final Model Significance *(p = 0.1 or less)*

Table 4.18

Estimated Marginal Means and Pairwise Comparisons for Impact of Health Information Technology (I-HIT)

Paired Sample

		Time 1				Time 2			
Independent Variable	Independent Variable Level	*M*	*SE*	*CI LL*	*CI UL*	*M*	*SE*	*CI LL*	*CI UL*
1) *General Advantages of Health Information Technology (HITGA)*									
Education Outside of USA	No	3.99_{a}	0.08	3.83	4.16				
Education Outside of USA	Yes	4.29_{b}	0.13	4.02	4.55				
Years HUP Tenure_Coded*Time	3 years or less	4.60	0.09	4.43	4.77	4.11	0.12	3.89	4.34
Years HUP Tenure_Coded*Time	5+ to 10 years	4.36	0.11	4.14	4.59	3.74	0.15	3.45	4.04
Years HUP Tenure_Coded*Time	20+ to 30 years	4.26	0.19	3.89	4.63	3.83	0.25	3.35	4.32
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	4.20_{a}	0.14	3.92	4.48				
Clinical Unit Type	Medical Unit	4.29_{a}	0.12	4.05	4.52				
Clinical Unit Type	Surgical Unit	4.16_{a}	0.12	3.93	4.39				
Clinical Unit Type	Intermediate Care	4.18_{a}	0.14	3.90	4.45				
Clinical Unit Type	Intensive Care Unit	3.79_{b}	0.11	3.58	4.00				
Clinical Unit Type	Women's Health	4.23_{ab}	0.16	3.91	4.55				
Clinical Unit Type*Time	Mixed Med-Surg / Outpatient Observation	4.36	0.15	4.07	4.64	4.04	0.19	3.67	4.42
Clinical Unit Type*Time	Surgical Unit	4.32	0.12	4.08	4.55	4.00	0.15	3.70	4.30
Clinical Unit Type*Time	Intensive Care Unit	4.21	0.11	4.00	4.43	3.37	0.14	3.09	3.65
Clinical Unit Type*Time	Women's Health	4.42	0.16	4.10	4.74	4.05	0.22	3.63	4.47
Race	White or Caucasian	3.90_{a}	0.09	3.72	4.08				

Race	Black or African American	4.15_{ab}	0.14	3.87	4.42				
Race	Asian, Pacific Island, Native American Indian Alaskan	4.37_{b}	0.13	4.11	4.63				
2) ***Workflow Implications of Health Information Technology (HITWF)***									
Education Outside of USA	No	4.38_{a}	0.07	4.24	4.53				
Education Outside of USA	Yes	4.67_{b}	0.13	4.40	4.93				
Clinical Ladder	Level 1	4.75_{a}	0.12	4.52	4.98				
Clinical Ladder	Level 2	4.49_{b}	0.08	4.34	4.65				
Clinical Ladder	Levels 3 & 4	4.33_{b}	0.11	4.11	4.54				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	4.58_{ab}	0.14	4.30	4.86				
Clinical Unit Type	Medical Unit	4.68_{a}	0.11	4.46	4.89				
Clinical Unit Type	Surgical Unit	4.55_{ab}	0.11	4.34	4.76				
Clinical Unit Type	Intermediate Care	4.54_{ab}	0.14	4.28	4.81				
Clinical Unit Type	Intensive Care Unit	4.26_{b}	0.11	4.05	4.47				
Clinical Unit Type	Women's Health	4.54_{ab}	0.17	4.21	4.87				
Clinical Unit Type*Time	Mixed Med-Surg / Outpatient Observation	4.77	0.14	4.49	5.05	4.39	0.19	4.02	4.75
Clinical Unit Type*Time	Surgical Unit	4.75	0.11	4.54	4.97	4.35	0.14	4.07	4.62
Clinical Unit Type*Time	Intermediate Care	4.69	0.14	4.43	4.96	4.40	0.18	4.05	4.74
Clinical Unit Type*Time	Intensive Care Unit	4.72	0.11	4.51	4.94	3.79	0.14	3.52	4.07
Clinical Unit Type*Time	Women's Health	4.72	0.17	4.40	5.05	4.36	0.22	3.93	4.78
Race	White or Caucasian	4.19_{a}	0.08	4.03	4.36				
Race	Black or African American	4.57_{b}	0.14	4.30	4.84				
Race	Asian, Pacific Island, Native American Indian Alaskan	4.81_{b}	0.13	4.55	5.06				
Race*Time	White or Caucasian	4.50	0.08	4.34	4.67	3.88	0.11	3.67	4.10

Race*Time	Asian, Pacific Island, Native American Indian Alaskan	4.98	0.13	4.73	5.24	4.63	0.17	4.30	4.97
3) *Information Tools to Support Communication Tasks (HITSCT)*									
Education Outside of USA	No	4.50_{a}	0.08	4.34	4.66				
Education Outside of USA	Yes	4.85_{b}	0.12	4.60	5.09				
Years HUP Tenure_Coded*Time	3 years or less	4.91	0.08	4.75	5.07	4.74	0.10	4.55	4.94
Years HUP Tenure_Coded*Time	5+ to 10 years	4.92	0.11	4.70	5.14	4.56	0.13	4.29	4.82
Shift	8, 10 or 12 hour Day Shift	4.80_{a}	0.09	4.62	4.97				
Shift	8, 10 or 12 hour Night Shift	4.56_{b}	0.09	4.39	4.73				
Shift	Rotate > 50% Shifts	4.66_{ab}	0.12	4.42	4.91				
Shift*Time	8, 10 or 12 hour Night Shift	4.65	0.09	4.47	4.84	4.82	0.11	4.60	5.04
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	4.79_{ab}	0.13	4.53	5.06				
Clinical Unit Type	Medical Unit	4.83_{a}	0.11	4.61	5.04				
Clinical Unit Type	Surgical Unit	4.59_{ab}	0.11	4.38	4.80				
Clinical Unit Type	Intermediate Care	4.64_{ab}	0.13	4.38	4.89				
Clinical Unit Type	Intensive Care Unit	4.50_{b}	0.10	4.31	4.69				
Clinical Unit Type	Women's Health	4.69_{ab}	0.15	4.40	4.99				
Clinical Unit Type*Time	Intensive Care Unit	4.66	0.10	4.45	4.86	4.34	0.12	4.10	4.58
Race	White or Caucasian	4.47_{a}	0.09	4.30	4.64				
Race	Black or African American	4.69_{ab}	0.13	4.44	4.94				
Race	Asian, Pacific Island, Native American Indian Alaskan	4.86_{b}	0.12	4.62	5.10				
Race*Time	White or Caucasian	4.59	0.09	4.41	4.77	4.35	0.11	4.14	4.56
4) *Information Tools to Support Information Tasks (HITSIT)*									
Education Outside of USA	No	3.91	0.09	3.72	4.09				
Education Outside of USA	Yes	4.33	0.16	4.02	4.64				

Clinical Unit Type*Time	Intensive Care Unit	4.30	0.14	4.02	4.57	3.59	0.15	3.30	3.88
Race	White or Caucasian	3.71_a	0.10	3.51	3.91				
Race	Black or African American	4.25_b	0.16	3.92	4.57				
Race	Asian, Pacific Island, Native American Indian Alaskan	4.40_b	0.15	4.10	4.70				
5) *HIT Depersonalizes Care (HITDPC)*									
Clinical Unit Type*Time	Medical Unit	3.70	0.26	3.20	4.20	4.37	0.28	3.81	4.93
Ethnicity	Hispanic or Latino	4.23_a	0.35	3.53	4.92				
Ethnicity	Non-Hispanic or Latino	3.63_b	0.09	3.45	3.81				
Ethnicity*Time	Non-Hispanic or Latino	3.82	0.10	3.62	4.03	3.44	0.12	3.21	3.67
Race	White or Caucasian	4.04_a	0.18	3.68	4.39				
Race	Black or African American	4.19_a	0.24	3.71	4.67				
Race	Asian, Pacific Island, Native American Indian Alaskan	3.56_b	0.24	3.09	4.04				

M = Mean
SE = Standard error
CI LL = Confidence Interval Lower Limit
CI UL = Confidence Interval Upper Limit

Table 4.19

Parameter Estimates for Final Repeated Measures GLM Models for Impact of Health Information Technology (I-HIT) Paired Sample

Continuous Independent Variable	Phase	B	Std. Error	*p**	*CI LL*	*CI UL*	Partial Eta Squared
General Advantages of Health Information Technology (HITGA)							
Hours Per Pay Period*Time	1	.001	.002	.789	-.004	.005	.000
Hours Per Pay Period*Time	2	.006	.003	**.032**	.001	.012	.012
Information Tools to Support Communication Tasks (HITSCT)							
Hours Per Pay Period	1	.003	.002	.183	-.001	.007	.004
Hours Per Pay Period	2	.004	.003	**.078**	-.001	.009	.008
HIT Depersonalizes Care (HITDPC)							
Hours Per Pay Period*Time	1	-.004	.004	.325	-.011	.004	.003
Hours Per Pay Period*Time	2	.009	.004	**.037**	.001	.017	.011

B = Beta coefficient

p = Final Model Significance *(p = 0.1 or less)*

CI LL= Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Univariate GLM Models for I-HIT for the Independent Sample

Final I-HIT univariate GLM regression model summary results for the independent sample are provided in Table 4.20. Estimated marginal means and pairwise comparisons for the I-HIT independent sample are presented in Table 4.21. Parameter estimates for continuous independent variables included in final I-HIT independent sample regression models are summarized in Table 4.22.

The univariate GLM results for the *General Advantages of HIT* (*HITGA*) subscale was very similar to the RM GLM for the paired sample with main effects *EDOUT* $F(1, 551) = 2.90$, p .089; *CU* $F(5, 551) = 8.78$, $p < .001$; *CU*Group* $F(5, 551) = 5.26$, $p < .001$; *Race* $F(2, 551) = 6.83$, $p < .001$; and *Clinical Ladder (CLADD*) $F(2, 551) = 5.10$, $p = .006$. Consistent with the RM I-HIT models, internationally educated nurses held more positive views of *HITGA* than their counterparts. Nurses who worked in ICU ($M = 3.80$) and WH ($M = 4.04$) clinical units continued to report lower satisfaction than their colleagues in Medical Units ($M = 4.58$), who were the most satisfied with *HITGA*. However, nurses working across nearly all unit types demonstrated decreased satisfaction across time after the CDSS implementation. Consistent with the RM regression model outcomes, novice nurses (Level 1) ($M = 4.33$) were more satisfied than the competent (Level 2) ($M = 4.17$) and expert nurses (Levels 3 & 4) ($M = 4.03$). Nurses who reported having *Prior Clinical Documentation System Experience (CLINDOC)* $F(1, 551) = 7.32$, $p = .007$ were more likely to be satisfied with *HITGA* than those who reported not having prior experience.

The univariate GLM results for *Workflow Implications of HIT* (*HITWF*) were mostly consistent with the RM regression results. *CLADD* $F(2, 551) = 6.53$, $p = .002$ continued to show that novice nurses ($M = 4.94$) were more satisfied than their Levels 2 ($M = 4.55$) and Levels 3 & 4 ($M =$ and 4.48) colleagues. Nurses working in Medical units ($M = 5.99$) continued to be the most satisfied and contrasted with those working in ICU ($M = 4.18$) and WH ($M = 4.62$) units

who reported the lowest mean subscale scores. However, Medical unit nurse satisfaction did decrease post CDSS implementation. Whites and Non-Hispanics reported lower satisfaction than the other racial and ethnic groups. Post hoc comparisons for *CLINDOC* $F(1, 551) = 8.97$, $p = .003$ showed that prior electronic clinical documentation system experience predicted higher *HITWF* subscale scores.

The univariate regression results for *Information Tools to Support Information Tasks* (*HITSIT*) were generally consistent with those from the RM regression model with a few notable exceptions. *EDOUT* $F(1, 528) = 6.57$, $p = .049$ indicated that nurses educated outside the USA were more satisfied than those educated domestically. Further, *Education (ED)* $F(2,528) = 3.04$, $p = .021$ was a main-effect with *HITSIT*. Post hoc comparisons demonstrated that nurses prepared with a bachelor's degree ($M = 4.28$) were more satisfied than those holding a master's or doctoral degree ($M = 3.94$).*CU* $F(5, 528) = 4.80$, $p < .001$. Nurses working in Medical units reported the highest mean satisfaction scores ($M = 4.44$), while those working in ICUs reported the lowest scores ($M = 3.84$). Non-Hispanic and White nurses continued to report less satisfaction than other ethnic and racial groups.

The univariate GLM main-effect and interaction variable results for *HIT Depersonalizes Care* (*HITDPC*) were generally consistent with the results of the RM *HITDPC*. *EDOUT* $F(1, 538) = 5.99$, $p = .015$ continued to demonstrate that domestically educated nurses are less satisfied than their internationally educated peers; the US educated group also decreased post CDSS implementation *EDOUT**Group $F(1, 538) = 5.00$, $p = .015$. Nurses working in ICU units reported the lowest mean *HITDPC* scores among the unit types; ICU satisfaction also decreased over time *CU*Group* $F(5, 538) = 3.26$, $p = .007$. Non-Hispanic nurses continued to report lower *HITDPC* scores than Hispanics.

Table 4.20

Final Univariate GLM Model Summary for I-HIT

Independent Sample

	Sum of Squares	Mean Square	*df*	*F*	*p**	Partial Eta Squared
1)*General Advantages of HIT (HITGA)*						
Education Outside of USA	2.71	2.71	1.0	2.90	.089	.005
Clinical Ladder	9.52	4.76	2.0	5.10	.006	.018
Clinical Unit Type	40.9	8.20	5.0	8.78	.000	.074
Clinical Unit Type*Group	24.6	4.91	5.0	5.26	<.001	.046
Race	12.75	6.37	2.0	6.83	<.001	.024
Prior electronic clin doc system exp.	6.83	6.83	1.0	7.32	.007	.013
Error	514	.933	551			
2)*Workflow Implications of HIT (HITWF)*						
Clinical Ladder	13.75	6.88	2.0	6.53	.002	.023
Clinical Unit Type	41.6	8.32	5.0	7.89	<.001	.067
Clinical Unit Type*Group	24.7	4.94	5.0	4.69	<.001	.041
Ethnicity*Group	4.08	4.08	1.0	3.88	.049	.007
Race	19.1	9.56	2.0	9.07	<.001	.032
Prior electronic clin doc system exp.	9.26	9.26	1.0	8.79	.003	.016
Error	580	1.05	551			
3) *Information Tools to Support Communication Tasks (HITSCT)*						
Education	6.36	3.18	2.0	3.87	.021	.014
Education Outside of USA*Group	4.02	4.02	1.0	4.90	.027	.009
Clinical Ladder	3.92	1.96	2.0	2.39	.093	.009
Shift	4.02	2.01	2.0	2.45	.088	.009
Shift*Group	6.37	3.19	2.0	3.88	.021	.014
Clinical Unit Type	17.2	3.44	5.0	4.19	.001	.037
Clinical Unit Type*Group	12.7	2.54	5.0	3.10	.009	.028
Race	11.6	5.82	2.0	7.09	.001	.025
Error	445	.821	542			
4) *Information Tools to Support Information Tasks (HITSIT)*						
Education	8.40	4.20	2.0	3.04	.049	.011
Education Outside of USA	9.07	9.07	1.0	6.57	.011	.012
Clinical Ladder*Group	8.53	4.26	2.0	3.09	.046	.012
Shift*Group	10.8	5.42	2.0	3.93	.020	.015
Clinical Unit Type	33.1	6.63	5.0	4.80	<.001	.043
Clinical Unit Type*Group	18.6	3.73	5.0	2.70	.020	.025
Ethnicity	4.55	4.55	1.0	3.30	.070	.006
Ethnicity*Group	6.86	6.86	1.0	4.97	.026	.009

Race	19.8	9.89	2.0	7.16	.001	.026
Error	729	1.38	528			
5) *HIT Depersonalizes Care (HITDPC)*						
Education Outside of USA*Group	11.9	11.9	1.0	5.99	.015	.011
Shift*Group	18.5	9.24	2.0	4.66	.010	.017
Clinical Unit Type*Group	32.3	6.46	5.0	3.26	.007	.029
Ethnicity	9.33	9.33	1.0	4.71	.030	.009
Hours per pay period*Group	7.47	7.47	1.0	3.77	.053	.007
Error	1065	1.98	538			

df = Degrees of freedom

F = F distribution

p = Final Model Significance *(p = 0.1 or less)*

Table 4.21

Estimated Marginal Means and Pairwise Comparisons for Impact of Health Information Technology (I-HIT) Independent Sample

		Time 1				Time 2			
Independent Variable	Independent Variable Level	*M*	*SE*	*CI LL*	*CI UL*	*M*	*SE*	*CI LL*	*CI UL*
1) *General Advantages of Health Information Technology (HITGA)*									
Education Outside of USA	No	4.10_{a}	0.07	3.96	4.25				
Education Outside of USA	Yes	4.33_{b}	0.13	4.08	4.58				
Clinical Ladder	Level 1	4.46_{a}	0.11	4.23	4.68				
Clinical Ladder	Level 2	4.17_{b}	0.08	4.02	4.32				
Clinical Ladder	Levels 3 & 4	4.03_{b}	0.12	3.79	4.27				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	4.16_{a}	0.12	3.92	4.39				
Clinical Unit Type	Medical Unit	4.58_{c}	0.11	4.36	4.80				
Clinical Unit Type	Surgical Unit	4.41_{a}	0.11	4.18	4.63				
Clinical Unit Type	Intermediate Care	4.32_{a}	0.15	4.03	4.61				
Clinical Unit Type	Intensive Care Unit	3.80_{b}	0.11	3.59	4.02				
Clinical Unit Type	Women's Health	4.04_{ab}	0.16	3.72	4.36				
Clinical Unit Type*Group	Mixed Med-Surg / Outpatient Observation	4.47	0.16	4.15	4.79	3.84	0.14	3.56	4.12
Clinical Unit Type*Group	Intermediate Care	4.73	0.20	4.33	5.12	3.92	0.19	3.54	4.29
Clinical Unit Type*Group	Intensive Care Unit	4.22	0.14	3.95	4.50	3.38	0.13	3.13	3.64
Clinical Unit Type*Group	Women's Health	4.50	0.24	4.04	4.96	3.58	0.21	3.17	3.99
Race	White or Caucasian	4.00_{a}	0.08	3.84	4.16				
Race	Black or African American	4.43_{b}	0.13	4.17	4.68				

Race	Asian, Pacific Island, Native American Indian Alaskan	4.23_{a}	0.13	3.97	4.48				
Prior electronic clin doc system exp.	Yes	4.33_{a}	0.09	4.15	4.52				
Prior electronic clin doc system exp.	No	4.10_{b}	0.09	3.93	4.27				
2) *Workflow Implications of Health Information Technology (HITWF)*									
Clinical Ladder	Level 1	4.94_{a}	0.17	4.60	5.27				
Clinical Ladder	Level 2	4.55_{b}	0.14	4.27	4.82				
Clinical Ladder	Levels 3 & 4	4.48_{b}	0.18	4.14	4.83				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	4.71_{b}	0.17	4.38	5.04				
Clinical Unit Type	Medical Unit	4.99_{b}	0.17	4.66	5.33				
Clinical Unit Type	Surgical Unit	4.70_{b}	0.17	4.37	5.02				
Clinical Unit Type	Intermediate Care	4.73_{b}	0.19	4.35	5.11				
Clinical Unit Type	Intensive Care Unit	4.18_{a}	0.16	3.87	4.50				
Clinical Unit Type	Women's Health	4.62_{ab}	0.21	4.20	5.04				
Clinical Unit Type*Group	Medical Unit	4.64	0.22	4.21	5.07	5.34	0.25	4.85	5.84
Ethnicity*Group	Non-Hispanic or Latino	4.72	0.09	4.54	4.90	4.23	0.08	4.07	4.40
Race	White or Caucasian	4.37_{a}	0.14	4.09	4.66				
Race	Black or African American	4.86_{b}	0.17	4.52	5.20				
Race	Asian, Pacific Island, Native American Indian Alaskan	4.73_{b}	0.18	4.37	5.09				
Prior electronic clin doc system exp.	Yes	4.79_{a}	0.16	4.48	5.10				
Prior electronic clin doc system exp.	No	4.52_{b}	0.14	4.24	4.80				
3) *Information Tools to Support Communication Tasks (HITSCT)*									
Education	Diploma and Associate	4.35_{ab}	0.21	3.94	4.76				
Education	Bachelor	4.64_{a}	0.08	4.47	4.80				

Education	Master and Doctorate	4.33_{b}	0.13	4.08	4.58				
Education Outside of USA*Group	No	4.43	0.11	4.22	4.64	4.26	0.10	4.05	4.46
Clinical Ladder	Level 1	4.59_{a}	0.13	4.34	4.84				
Clinical Ladder	Level 2	4.37_{b}	0.10	4.17	4.57				
Clinical Ladder	Levels 3 & 4	4.35_{ab}	0.12	4.11	4.60				
Shift	8, 10 or 12 hour Day Shift	4.49_{a}	0.10	4.28	4.69				
Shift	8, 10 or 12 hour Night Shift	4.55_{b}	0.11	4.34	4.75				
Shift	Rotate > 50% Shifts	4.28_{a}	0.13	4.02	4.54				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	4.34_{b}	0.13	4.09	4.59				
Clinical Unit Type	Medical Unit	4.77_{a}	0.12	4.52	5.01				
Clinical Unit Type	Surgical Unit	4.35_{b}	0.12	4.10	4.59				
Clinical Unit Type	Intermediate Care	4.59_{ab}	0.15	4.30	4.88				
Clinical Unit Type	Intensive Care Unit	4.28_{b}	0.12	4.05	4.51				
Clinical Unit Type	Women's Health	4.30_{ab}	0.17	3.97	4.63				
Clinical Unit Type*Group	Surgical Unit	4.03	0.18	3.68	4.38	4.66	0.14	4.38	4.95
Race	White or Caucasian	4.23_{a}	0.10	4.04	4.42				
Race	Black or African American	4.64_{b}	0.14	4.37	4.91				
Race	Asian, Pacific Island, Native American Indian Alaskan	4.44_{ab}	0.13	4.18	4.70				
4) ***Information Tools to Support Information Tasks (HITSIT)***									
Education	Diploma and Associate	3.89_{ab}	0.31	3.29	4.49				
Education	Bachelor	4.28_{a}	0.18	3.93	4.63				
Education	Master and Doctorate	3.94_{b}	0.22	3.51	4.37				
Education Outside of USA	No	3.83_{a}	0.19	3.46	4.19				
Education Outside of USA	Yes	4.25_{b}	0.22	3.81	4.69				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	4.02_{ab}	0.22	3.60	4.45				

Clinical Unit Type	Medical Unit	4.44_{a}	0.21	4.01	4.86				
Clinical Unit Type	Surgical Unit	4.08_{ab}	0.22	3.65	4.50				
Clinical Unit Type	Intermediate Care	4.18_{ab}	0.24	3.70	4.65				
Clinical Unit Type	Intensive Care Unit	3.68_{b}	0.21	3.27	4.08				
Clinical Unit Type	Women's Health	3.84_{ab}	0.26	3.33	4.35				
Clinical Unit Type*Group	Medical Unit	4.11	0.27	3.58	4.64	4.76	0.31	4.15	5.37
Clinical Unit Type*Group	Surgical Unit	3.70	0.29	3.14	4.27	4.45	0.29	3.88	5.01
Ethnicity	Hispanic or Latino	4.31_{a}	0.32	3.69	4.94				
Ethnicity	Non-Hispanic or Latino	3.76_{b}	0.13	3.51	4.01				
Ethnicity*Group	Non-Hispanic or Latino	4.03	0.15	3.74	4.31	3.50	0.15	3.21	3.79
Race	White or Caucasian	3.75_{a}	0.20	3.37	4.14				
Race	Black or African American	4.29_{b}	0.23	3.85	4.74				
Race	Asian, Pacific Island, Native American Indian Alaskan	4.07_{ab}	0.22	3.63	4.50				
5) *HIT Depersonalizes Care (HITDPC)*									
Education Outside of USA*Group	No	3.59	0.19	3.21	3.96	3.24	0.19	2.88	3.61
Shift*Group	8, 10 or 12 hour Day Shift	3.15	0.22	2.71	3.60	3.56	0.23	3.11	4.01
Shift*Group	8, 10 or 12 hour Night Shift	3.45	0.24	2.98	3.92	3.03	0.23	2.57	3.48
Clinical Unit Type*Group	Mixed Med-Surg / Outpatient Observation	3.00	0.29	2.42	3.57	3.62	0.27	3.08	4.16
Clinical Unit Type*Group	Intensive Care Unit	3.47	0.25	2.98	3.95	2.69	0.24	2.22	3.17
Ethnicity	Hispanic or Latino	2.93_{a}	0.34	2.27	3.59				
Ethnicity	Non-Hispanic or Latino	3.66_{b}	0.10	3.45	3.86				

M = Mean

SE = Standard error

CI LL = Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Table 4.22

Parameter Estimates for Final Univariate GLM Models for Impact of Health Information Technology (I-HIT) Independent Sample*

Continuous Independent Variable	Phase	B	Std. Error	*p**	*CI LL*	*CI UL*	Partial Eta Squared
HIT Depersonalizes Care (HITDPC)							
Hours Per Pay Period		.005	.004	.159	-.002	.012	.004
Hours Per Pay Period*Group	1	-.011	.006	**.053**	-.023	.000	.007
Hours Per Pay Period*Group	2	0					

B = Beta coefficient

p = Final Model Significance *(p = 0.1 or less)*

CI LL= Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Repeated Measures GLM Models for EOM II for the Paired Sample

Final EOM II GLM regression model summary results for the paired sample are provided in Table 4.23. Estimated marginal means and pairwise comparisons for the EOM II paired sample are presented in Table 4.24. Parameter estimates for continuous independent variables included in final EOM II paired sample regression models are summarized in Table 4.25.

The variance in the *Nurse-Physician Relationships* (*RNMD*) subscale was explained by five main-effects. Post hoc comparisons show that the results for *EDOUT* $F(1, 416) = 5.43$, $p = .020$, *CLADD* $F(5, 416) = 4.16$, $p = .016$; and *Race* $F(2, 416) = 2.83$, $p = .060$ were consistent with I-HIT models. However, *CU* demonstrated that ICU nurses held more favorable views of *RNMD* relationships than other unit types, as compared to the I-HIT regression models where ICU and WH consistently reported the lowest mean subscale scores. *HUPTEN* showed that nurses in the 5^{+} to 10 years of institutional experience group were significantly less satisfied with *RNMD* than any other group. Perhaps most notable is that none of the main-effect variables demonstrated an interaction with time; demonstrating that pre-implementation differences existed among between-group factors, but these differences remained stable post-implementation.

The *Support for Education* (*SuppED*) model variance was explained by two main-effects, *CU* $F(5, 416) = 4.17$, $p = .001$; and *Shift* $F(2, 416) = 6.01$, $p = .003$; and an interaction between *Race*Time* $F(2, 416) = 3.39$, $p = .035$. Consistent with *RNMD,* nurses in ICU and WH units reported the highest satisfaction with *SuppED*, but did not change from pre- to post-implementation. Whites and Asian racial groups did report increased satisfaction post CDSS implementation, while Blacks did not. Nurses who reported working day shift demonstrated higher subscale means than those working nights; nurses who reported rotating shifts were not different from either days or nights in post hoc comparisons. Pre-implementation differences in *Shift* did not change over time.

The *Clinical Autonomy (AUTO)* variance was explained by one main-effect *Shift* $F(2, 423) = 12.9$, $p < .001$; and one interaction variable *Total Years Experience*Time* (*YrsEXP*Time*) $F(6, 423) = 1.87$, $p = .084$. Nurses working days ($M = 82.60$) reported higher *AUTO* subscale mean scores than those working nights ($M = 77.15$); nurses who reported rotating shifts were not different from days or nights in post hoc comparisons. Nurses who reported having *Total Years Experience* 0 to 5 years, and 15 to 30 years (the low and high ends of the experience range) demonstrated increases in *AUTO* mean subscale scores from pre- to post-implementation. The CDSS implementation did not impact the perceptions of *AUTO* in nurses with experience in the middle of the range (5^{+} to 15 years).

Control Over Nursing Practice (*CNP*) variance was explained by two main-effect variables: *CLADD* $F(2, 419) = 3.04$, $p = .049$; and *Shift* $F(2, 419) = 14.7$, $p < .001$. Expert nurses (Levels 3 & 4) ($M = 76.01$) were less satisfied with *CNP* than competent (Level 2) ($M = 77.77$) and novice (Level 1) ($M = 79.9$) nurses—who were not statistically different from one another in post hoc comparisons. Mean subscale scores for neither *CLADD,* nor *Shift* changed post CDSS implementation.

Professional Practice Satisfaction (PPS) was explained by three main-effect and one interaction variables: *CLADD* $F(2, 416) = 2.80$, $p = .062$; *Shift* $F(2, 416) = 12.6$, $p < .001$; *CU* $F(5, 416) = 3.22$, $p = .007$; and *Race*Time* $F(2, 416) = 3.67$, $p = .026$. Mean *PPS* subscale scores demonstrated that novice nurses (Level 1) ($M = 323$) were more satisfied than competent (Level 2) ($M = 313$) and expert nurses (Levels 3 & 4) ($M = 314$). However, the expert group was not statistically different from either group. Nurses who worked days ($M = 324$) and rotated shifts ($M = 321$) were more satisfied than those who reported working night shift ($M = 305$). Comparisons among *Race* categories showed that White nurse perceptions of *PPS* increased from pre- ($M = 312$) to post- ($M = 320$) CDSS implementation.

Table 4.23

Final Repeated Measures GLM Model Summary for EOM II

Paired Sample

	Sum of Squares	Mean Square	*df*	*F*	*p**	Partial Eta Squared
1) *Nurse-Physician Relationships (RNMD)*						
Education Outside of USA	456	456	1	5.43	.020	.013
Years HUP Tenure_Coded	974	162	6	1.94	.074	.027
Clinical Ladder	699	349	2	4.16	.016	.020
Clinical Unit Type	3,872	774	5	9.22	<.001	.100
Race	475	237	2	2.83	.060	.013
Error	34,934	83.9	416			
2) *Support for Education (SuppED)*						
Shift	53.7	26.8	2	6.01	.003	.028
Clinical Unit Type	93.1	18.6	5	4.17	.001	.047
Race*Time	10.6	5.32	2	3.39	.035	.016
Error	1,890	83.9	416			
3) *Clinical Autonomy (AUTO)*						
Total Years Experience_Coded*Time	597	99.6	6	1.87	.084	.024
Shift	5,457	2,728	2	12.9	<.001	.054
Error	94,982	4.47	423			
4) *Control Over Nursing Practice (CNP)*						
Clinical Ladder	1,189	594	2	3.04	.049	.014
Shift	5,742	2,871	2	14.7	<.001	.065
Error	81,977	196	419			
5) *Perception that Staffing is Adequate (STAFF)*						
Clinical Ladder*Time	33.9	16.9	2	6.22	.002	.029
Shift	68.3	34.2	2	3.06	.048	.014
Clinical Unit Type	356	71.3	5	6.38	<.001	.071
Clinical Unit Type*Time	56.6	11.3	5	4.15	.001	.047
Error	4,668	11.2	419			
6) *Working with Clinically Competent Peers (CCP)*						
Clinical Ladder	35.6	17.8	2	3.68	.026	.017
Shift	26.5	13.2	2	2.74	.066	.013
Shift*Time	11.2	5.59	2	4.11	.017	.019
Clinical Unit Type	61.6	12.3	5	2.55	.028	.030
Hours per pay period*Time	5.81	5.81	1	4.27	.040	.010
Error	2,008	4.83	415			
7) *Nurse Manager Support Index (NMS)*						

Total Years Experience_Continuous	710	710.1	1	10.78	.001	.025
Clinical Ladder*Time	82.1	41.07	2	2.72	.067	.013
Shift	2,351	1,175	2	17.85	<.001	.079
Shift*Time	82.4	41.22	2	2.73	.066	.013
Clinical Unit Type	854	170.9	5	2.59	.025	.030
Clinical Unit Type*Time	174	34.90	5	2.32	.043	.027
Prior electronic clin doc system exp*Time	193	193.7	1	12.85	<.001	.030
Error	27,399	65.8	415			
8) *Patient-Centered Cultural Values (PCV)*						
Total Years Experience_Coded*Time	119	19.8	6	2.69	.014	.038
Clinical Ladder	334	167	2	5.77	.003	.027
Clinical Ladder*Time	46.4	23.2	2	3.15	.044	.015
Shift	331	165	2	5.72	.004	.027
Clinical Unit Type	443	88.7	5	3.06	.010	.036
Clinical Unit Type*Time	75.4	15.1	5	2.05	.071	.024
Hours per pay period	118	118	1	4.10	.044	.010
Error	11,838	29.0	408			
9) *Professional Practice Satisfaction (PPS)*						
Clinical Ladder	12,225	6,112	2	2.80	.062	.013
Shift	55,131	2,756	2	12.6	<.001	.057
Clinical Unit Type	35,095	7,019	5	3.22	.007	.037
Race*Time	3,096	1,548	2	3.67	.026	.017
Error	9,083	2,183	416			
10) *Nurse-Assessed Quality of Patient Care on Unit (QoC)*						
Shift	41.8	20.9	2	9.66	<.001	.044
Clinical Unit Type	46.0	9.21	5	4.26	.001	.048
Clinical Unit Type*Time	8.41	1.68	5	2.73	.019	.032
Age	12.9	12.9	1	6.00	.015	.014
Error	9,058	2.16	419			

df = Degrees of freedom

F = F distribution

p = Final Model Significance *(p = 0.1 or less)*

Table 4.24

Estimated Marginal Means and Pairwise Comparisons for Essentials of Magnetism II (EOM II)

Paired Sample

		Time 1				Time 2			
Independent Variable	Independent Variable Level	*M*	*SE*	*CI LL*	*CI UL*	*M*	*SE*	*CI LL*	*CI UL*
1) *Nurse-Physician Relationships (RNMD)*									
Education Outside of USA	No	47.68_{a}	0.71	46.28	49.07				
Education Outside of USA	Yes	45.06_{b}	1.13	42.84	47.28				
Years HUP Tenure_Coded	3 years or less	46.21_{ab}	0.79	44.65	47.77				
Years HUP Tenure_Coded	3+ to 5 years	46.41_{ab}	0.98	44.49	48.34				
Years HUP Tenure_Coded	5+ to 10 years	44.74_{a}	0.97	42.83	46.65				
Years HUP Tenure_Coded	10+ to 15 years	46.78_{ab}	1.38	44.07	49.49				
Years HUP Tenure_Coded	15+ to 20 years	44.32_{ab}	1.63	41.12	47.52				
Years HUP Tenure_Coded	20+ to 30 years	44.69_{ab}	1.61	41.51	47.86				
Years HUP Tenure_Coded	30 years or more	51.42_{b}	2.27	46.96	55.88				
Clinical Ladder	Level 1	47.12_{a}	1.20	44.76	49.47				
Clinical Ladder	Level 2	45.03_{b}	0.85	43.36	46.69				
Clinical Ladder	Levels 3 & 4	46.96_{ab}	0.90	45.19	48.72				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	46.58a	1.17	44.28	48.88				
Clinical Unit Type	Medical Unit	46.90_{b}	0.98	44.98	48.82				
Clinical Unit Type	Surgical Unit	44.91_{a}	0.95	43.04	46.78				
Clinical Unit Type	Intermediate Care	47.60_{c}	1.17	45.29	49.91				
Clinical Unit Type	Intensive Care Unit	49.79_{d}	0.93	47.96	51.62				

Clinical Unit Type	Women's Health	42.43_{acd}	1.37	39.73	45.12				
Race	White or Caucasian	45.35_{a}	0.79	43.80	46.89				
Race	Black or African American	47.75_{b}	1.14	45.50	50.00				
Race	Asian, Pacific Island, Native American Indian Alaskan	46.00_{ab}	1.10	43.83	48.17				
2) *Support for Education (SuppED)*									
Shift	8, 10 or 12 hour Day Shift	12.43_{a}	0.14	12.16	12.69				
Shift	8, 10 or 12 hour Night Shift	11.84_{b}	0.15	11.54	12.13				
Shift	Rotate > 50% Shifts	12.22_{ab}	0.19	11.84	12.60				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	12.32_{ab}	0.25	11.84	12.81				
Clinical Unit Type	Medical Unit	12.02_{ab}	0.18	11.67	12.38				
Clinical Unit Type	Surgical Unit	11.64_{a}	0.17	11.30	11.98				
Clinical Unit Type	Intermediate Care	12.71_{b}	0.23	12.26	13.15				
Clinical Unit Type	Intensive Care Unit	12.34_{ab}	0.16	12.02	12.66				
Clinical Unit Type	Women's Health	11.94_{ab}	0.29	11.37	12.50				
Race*Time	White or Caucasian	12.11	0.11	11.89	12.32	12.33	0.12	12.10	12.56
Race*Time	Asian, Pacific Island, Native American Indian Alaskan	11.75	0.25	11.26	12.25	12.28	0.27	11.74	12.82
3) *Clinical Autonomy (AUTO)*									
Total Years Experience_Coded*Time	3 years or less	79.28	0.92	77.47	81.08	81.38	0.90	79.60	83.15
Total Years Experience_Coded*Time	3+ to 5 years	78.20	1.31	75.63	80.77	80.82	1.29	78.29	83.35
Total Years Experience_Coded*Time	15+ to 20 years	76.73	2.00	72.80	80.66	82.34	1.96	78.48	86.20
Total Years Experience_Coded*Time	20+ to 30 years	80.36	1.96	76.50	84.22	84.89	1.93	81.10	88.68

Shift	8, 10 or 12 hour Day Shift	82.60_{a}	0.75	81.13	84.06				
Shift	8, 10 or 12 hour Night Shift	77.15_{b}	0.91	75.36	78.94				
Shift	Rotate > 50% Shifts	82.39_{a}	1.29	79.85	84.92				
4) *Control Over Nursing Practice (CNP)*									
Clinical Ladder	Level 1	79.90_{a}	1.12	77.69	82.11				
Clinical Ladder	Level 2	77.77_{a}	0.73	76.34	79.20				
Clinical Ladder	Levels 3 & 4	76.01_{b}	1.14	73.77	78.24				
Shift	8, 10 or 12 hour Day Shift	79.69_{a}	0.74	78.24	81.13				
Shift	8, 10 or 12 hour Night Shift	73.99_{b}	0.96	72.11	75.88				
Shift	Rotate > 50% Shifts	80.00_{a}	1.22	77.61	82.38				
5) *Perception that Staffing is Adequate (STAFF)*									
Clinical Ladder*Time	Level 1	17.56	0.30	16.96	18.16	16.95	0.30	16.37	17.54
Clinical Ladder*Time	Level 2	17.03	0.20	16.64	17.41	17.50	0.19	17.12	17.87
Shift	8, 10 or 12 hour Day Shift	17.75_{a}	0.18	17.40	18.09				
Shift	8, 10 or 12 hour Night Shift	17.08_{b}	0.23	16.63	17.53				
Shift	Rotate > 50% Shifts	17.52_{ab}	0.29	16.95	18.09				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	16.78_{acd}	0.37	16.05	17.50				
Clinical Unit Type	Medical Unit	17.50_{abcd}	0.27	16.96	18.04				
Clinical Unit Type	Surgical Unit	17.53_{dba}	0.26	17.01	18.04				
Clinical Unit Type	Intermediate Care	18.50_{b}	0.35	17.81	19.18				
Clinical Unit Type	Intensive Care Unit	18.25_{b}	0.22	17.81	18.69				
Clinical Unit Type	Women's Health	16.15_{ca}	0.45	15.27	17.03				
Clinical Unit Type*Time	Medical Unit	17.86	0.31	17.25	18.46	17.15	0.30	16.56	17.73
6) *Working with Clinically Competent Peers (CCP)*									
Clinical Ladder	Level 1	12.92_{a}	0.18	12.57	13.27				
Clinical Ladder	Level 2	12.45_{b}	0.11	12.22	12.67				

Clinical Ladder	Levels 3 & 4	12.28_{b}	0.18	11.92	12.63				
Shift	8, 10 or 12 hour Day Shift	12.75_{a}	0.12	12.52	12.98				
Shift	8, 10 or 12 hour Night Shift	12.33_{b}	0.15	12.04	12.63				
Shift	Rotate > 50% Shifts	12.56_{ab}	0.19	12.18	12.94				
Shift*Time	8, 10 or 12 hour Day Shift	12.53	0.13	12.27	12.79	12.97	0.13	12.71	13.22
7) *Nurse Manager Support Index (NMS)*									
Clinical Ladder*Time	Level 2	36.16	0.47	35.23	37.08	36.84	0.48	35.90	37.78
Shift	8, 10 or 12 hour Day Shift	37.72_{a}	0.44	36.86	38.58				
Shift	8, 10 or 12 hour Night Shift	34.12_{b}	0.57	32.99	35.24				
Shift	Rotate > 50% Shifts	38.34_{a}	0.71	36.94	39.74				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	37.46_{ab}	0.89	35.70	39.21				
Clinical Unit Type	Medical Unit	37.03_{ab}	0.67	35.71	38.35				
Clinical Unit Type	Surgical Unit	35.21_{a}	0.64	33.94	36.47				
Clinical Unit Type	Intermediate Care	38.49_{b}	0.85	36.82	40.16				
Clinical Unit Type	Intensive Care Unit	36.06_{ab}	0.56	34.96	37.15				
Clinical Unit Type	Women's Health	36.11_{ab}	1.09	33.96	38.25				
Clinical Unit Type*Time	Intermediate Care	37.68	0.93	35.85	39.52	39.31	0.95	37.44	41.17
Prior electronic clin doc system exp*Time	Yes	37.10	0.56	36.00	38.20	35.91	0.57	34.79	37.03
Prior electronic clin doc system exp*Time	No	36.53	0.48	35.59	37.46	37.36	0.48	36.41	38.31
8) *Patient-Centered Values (PCV)*									
Total Years Experience_Coded*Time	3 years or less	33.29	0.43	32.44	34.13	33.98	0.44	33.12	34.85
Total Years Experience_Coded*Time	3+ to 5 years	32.66	0.60	31.49	33.84	33.66	0.61	32.45	34.86
Total Years Experience_Coded*Time	5+ to 10 years	34.26	0.59	33.10	35.42	33.21	0.60	32.02	34.40

Total Years Experience_Coded*Time	15+ to 20 years	32.58	0.81	30.98	34.18	33.80	0.83	32.16	35.43
Total Years Experience_Coded*Time	20+ to 30 years	34.27	0.79	32.71	35.83	35.52	0.81	33.93	37.11
Clinical Ladder	Level 1	35.31_{a}	0.63	34.06	36.55				
Clinical Ladder	Level 2	33.55_{b}	0.37	32.83	34.27				
Clinical Ladder	Levels 3 & 4	32.69_{b}	0.45	31.80	33.58				
Clinical Ladder*Time	Level 2	33.08	0.40	32.28	33.87	34.03	0.41	33.21	34.84
Clinical Ladder*Time	Levels 3 & 4	32.26	0.50	31.27	33.24	33.12	0.51	32.11	34.13
Shift	8, 10 or 12 hour Day Shift	34.48_{a}	0.34	33.81	35.16				
Shift	8, 10 or 12 hour Night Shift	32.98_{b}	0.40	32.19	33.78				
Shift	Rotate > 50% Shifts	34.08_{ab}	0.55	33.00	35.16				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	33.55_{ab}	0.63	32.31	34.79				
Clinical Unit Type	Medical Unit	34.39_{ab}	0.50	33.40	35.38				
Clinical Unit Type	Surgical Unit	33.23_{ab}	0.48	32.29	34.18				
Clinical Unit Type	Intermediate Care	34.91_{a}	0.61	33.72	36.11				
Clinical Unit Type	Intensive Care Unit	34.59_{a}	0.40	33.80	35.38				
Clinical Unit Type	Women's Health	32.41_{b}	0.75	30.94	33.88				
9) *Professional Practice Satisfaction (PPS) / Total EOM II*									
Clinical Ladder	Level 1	323_{a}	4.17	315	331				
Clinical Ladder	Level 2	313_{b}	2.93	307	319				
Clinical Ladder	Levels 3 & 4	314_{ab}	4.31	305	322				
Shift	8, 10 or 12 hour Day Shift	324_{a}	3.13	318	330				
Shift	8, 10 or 12 hour Night Shift	305_{b}	3.56	298	312				
Shift	Rotate > 50% Shifts	321_{a}	4.52	312	330				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	319_{ab}	5.51	308	330				

Clinical Unit Type	Medical Unit	317_{ab}	4.22	309	325				
Clinical Unit Type	Surgical Unit	309_{a}	3.93	301	316				
Clinical Unit Type	Intermediate Care	325_{b}	5.19	315	335				
Clinical Unit Type	Intensive Care Unit	324_{b}	3.81	316	331				
Clinical Unit Type	Women's Health	306_{ab}	6.52	294	319				
Race*Time	White or Caucasian	312	2.44	307	317	320	2.50	315	325
10) ***Nurse-Assessed Quality of Patient Care (QoC)***									
Shift	8, 10 or 12 hour Day Shift	8.50_{a}	0.08	8.35	8.65				
Shift	8, 10 or 12 hour Night Shift	8.02_{b}	0.09	7.83	8.21				
Shift	Rotate > 50% Shifts	8.53_{ab}	0.13	8.28	8.78				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	8.31_{ab}	0.16	7.99	8.63				
Clinical Unit Type	Medical Unit	8.37_{ab}	0.12	8.14	8.60				
Clinical Unit Type	Surgical Unit	8.29_{ab}	0.11	8.06	8.51				
Clinical Unit Type	Intermediate Care	8.68_{a}	0.15	8.39	8.97				
Clinical Unit Type	Intensive Care Unit	8.65_{a}	0.09	8.47	8.83				
Clinical Unit Type	Women's Health	7.81_{b}	0.20	7.42	8.19				
Clinical Unit Type*Time	Intermediate Care	8.37	0.18	8.03	8.71	8.99	0.16	8.68	9.31

M = Mean

SE = Standard error

CI LL = Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Table 4.25

Parameter Estimates for Final Repeated Measures GLM Models for Essentials of Magnetism (EOM II)

Paired Sample

Continuous Independent Variable	Phase	B	Std. Error	*p**	*CI LL*	*CI UL*	Partial Eta Squared
Working with Clinically Competent Peers (CCP)							
Hours Per Pay Period*Time	1	.000	.005	.960	-.009	.010	.000
Hours Per Pay Period*Time	2	.010	.005	**.044**	.000	.019	.010
Nurse Manager Support Index (NMS)							
Years Total Experience	1	.116	.044	**.009**	.029	.202	.016
Years Total Experience	2	.148	.045	**.001**	.060	.236	.025
Patient-Centered Cultural Values (PCV)							
Hours Per Pay Period	1	.025	.012	**.034**	.002	.048	.011
Hours Per Pay Period	2	.018	.012	.135	-.006	.041	.005
Nurse-Assessed Quality of Care on Unit (QoC)							
Age	1	.011	.007	**.099**	-.002	.024	.006
Age	2	.016	.006	**.007**	.005	.028	.017

B = Beta coefficient

p = Final Model Significance *(p = 0.1 or less)*

CI LL= Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Univariate GLM Models for the EOM II for the Independent Sample

Final EOM II univariate GLM regression model summary results for the independent sample are provided in Table 4.26. Estimated marginal means and pairwise comparisons for the EOM II independent sample are presented in Table 4.27. Parameter estimates for continuous independent variables included in final EOM II independent sample regression models are summarized in Table 4.28.

The variance in the *Control Over Nursing Practice* (*CNP*) subscale was explained by six main-effect and two interaction variables. Univariate GLM showed main-effects from *Education* (*ED*) $F(2, 558) = 2.51$, $p = .082$; *EDOUT* $F(1, 558) = 3.35$, $p = .068$; *CLADD* $F(2, 558) = 2.72$, $p = .067$; *CU* $F(5, 558) = 3.54$, $p = .004$; *Shift* $F(2, 558) = 6.30$, $p = .002$; and *Prior Clinical Documentation Experience (CLINDOC)* $F(1, 558) = 14.9$, $p < .001$. Consistent with the I-HIT univariate GLM models, *ED* showed that nurses prepared at the highest levels with master's and doctorate degrees ($M = 77.94$) were less satisfied than those prepared at the baccalaureate level ($M = 80.88$). Internationally educated nurses ($M = 8.31$) reported higher overall *CNP* than those educated in the USA ($M = 78.85$). Novice (Level 1) nurses showed higher mean *CNP* scores than competent ($M = 78.85$) and expert (Levels 3 & 4) ($M = 79.45$), but expert nurses were not statistically different from the other groups despite the numerically higher mean subscale scores. Novice nurses did, however, increase in *CNP* from pre- to post- CDSS implementation. Comparisons showed that Intermediate and ICU units (*CU*) scored statistically higher on *CNP* subscale scores than *Surgical*. However, the remaining unit types (Medical, Mixed Medical, and Women's' Health) were not significantly different from either Intermediate or ICU. Consistent with other I-HIT and EOM II subscale GLM results, working day shift ($M = 81.59$) predicted higher *CNP* subscale scores as compared with the nurses working night shift ($M = 77.86$). Post hoc comparisons of *Sex*Time* showed that Female perceptions of *CNP* improved over time between pre- to post-implementation.

Working with Clinically Competent Peers (*CCP*) variance was explained by three main–effect and three interaction variables: *EDOUT* $F(1, 560) = 3.30$, $p = .070$; *CLADD* $F(2, 560) = 4.64$, $p = .010$; *CLINDOC* $F(1, 560) = 5.71$, $p = .017$; *CLADD*Group* $F(2, 560) = 2.66$, $p = .071$; *Sex*Group* $F(1, 560) = 11.3$, $p = .001$; and *Race*Group* $F(2, 560) = 2.55$, $p = .017$. Post hoc comparisons showed that nurses educated internationally ($M = 13.23$), Level 1 (novice) nurses ($M = 13.30$), and those with prior clinical documentation experience were more likely to perceive their peers as more competent as compared with their peers. Further, competent (Level 2) and expert (Levels 3 & 4) nurses viewed their peers as less competent post CDSS implementation. Female nurse perceptions of *CCP* increased from pre- to post-implementation, while male nurse perceptions of peer competence decreased.

Table 4.26

Final Univariate GLM Model Summary for EOM II

Independent Sample

	Sum of Squares	Mean Square	*df*	*F*	*p**	Partial Eta Squared
1)*Nurse-Physician Relationships (RNMD)*						
Education*Group	318	159	2.0	2.48	.085	.009
Clinical Unit Type	2,253	450	5.0	7.02	<.001	.058
Error	36,733	64.2	572			
2) *Support for Education (SuppED)*						
Years HUP Tenure_Coded	76.6	12.7	6.0	4.78	<.001	.049
Years HUP Tenure_Coded*Group	32.1	5.35	6.0	2.01	.063	.021
Shift	29.0	14.5	2.0	5.44	.005	.019
Clinical Unit Type	36.7	7.35	5.0	2.75	.018	.024
Sex*Group	10.9	10.9	1.0	4.07	.044	.007
Error	1,489	2.66	558			
3) *Clinical Autonomy(AUTO)*						
Education	1,142	571	2.0	4.69	.010	.016
Years HUP Tenure_Continuous	454	454	1.0	3.73	.054	.007
Clinical Ladder*Group	621	310	2.0	2.55	.079	.009
Shift	3,179	1,589	2.0	13.0	<.001	.044
Clinical Unit Type	1,282	256	5.0	2.11	.063	.018
Prior electronic clin doc system exp.	402	402	1.0	3.30	.070	.006
Error	68,731	121	564			
4) *Control Over Nursing Practice (CNP)*						
Education	575	287	2.0	2.51	.082	.009
Education Outside of USA	383	383	1.0	3.35	.068	.006
Clinical Ladder	621	311	2.0	2.72	.067	.010
Clinical Ladder*Group	744	372	2.0	3.25	.039	.012
Shift	1,441	721	2.0	6.30	.002	.022
Clinical Unit Type	2,026	405	5.0	3.54	.004	.031
Sex*Group	556	556	1.0	4.86	.028	.009
Prior electronic clin doc system exp.	1,707	1,707	1.0	14.9	<.001	.026
Error	63,861	114	558			
5) *Perception that Staffing is Adequate (STAFF)*						
Clinical Ladder	54.5	27.2	2.0	3.99	.019	.014
Shift	52.3	26.1	2.0	3.83	.022	.013
Clinical Unit Type	162.5	32.5	5.0	4.76	<.001	.041
Sex*Group	28.0	28.0	1.0	4.09	.044	.007
Race*Group	39.5	19.8	2.0	2.89	.056	.010

Error	3,825	6.83	560			
6) ***Working with Clinically Competent Peers (CCP)***						
Education Outside of USA	9.47	9.47	1.0	3.30	.070	.006
Clinical Ladder	26.6	13.3	2.0	4.64	.010	.016
Clinical Ladder*Group	15.3	7.63	2.0	2.66	.071	.009
Sex*Group	32.4	32.4	1.0	11.3	.001	.020
Race*Group	14.6	7.31	2.0	2.55	.079	.009
Prior electronic clin doc system exp.	16.4	16.4	1.0	5.71	.017	.010
Error	1,614	6.83	560			
7) ***Nurse Manager Support Index (NMS)***						
Total Years Experience_Coded	946	157	6.0	4.06	.001	.042
Total Years Experience_Coded*Group	666	111	6.0	2.86	.009	.030
Shift	506	253	2.0	6.52	.002	.023
Sex	139	139	1.0	3.60	.058	.006
Prior electronic clin doc system exp.	304	304	1.0	7.84	.005	.014
Error	21,820	38.8	562			
8) ***Patient-Centered Cultural Values (PCV)***						
Education	196	98.5	2.0	5.01	.007	.018
Education Outside of USA	197	197	1.0	10.0	.002	.018
Clinical Ladder	142	71.3	2.0	3.62	.027	.013
Clinical Ladder*Group	115	57.9	2.0	2.95	.053	.011
Shift	105	52.5	2.0	2.67	.070	.010
Clinical Unit Type	387	77.6	5.0	3.94	.002	.034
Clinical Unit Type*Group	187	37.5	5.0	1.91	.091	.017
Sex*Group	60.4	60.4	1.0	3.07	.080	.006
Hours per pay period*Group	96.0	96.0	1.0	4.88	.028	.009
Prior electronic clin doc system exp.	168	168	1.0	8.57	.004	.015
Error	10,878	19.7	553			
9) ***Professional Practice Satisfaction (PPS)/Total EOM II Score***						
Education	9,770	4,885	2.0	3.85	.022	.014
Education Outside of USA*Group	3,987	3,987	1.0	3.14	.077	.006
Clinical Ladder	7,020	3,510	2.0	2.76	.064	.010
Clinical Ladder*Group	7,126	3,563	2.0	2.81	.061	.010
Shift	22,104	11,052	2.0	8.70	<.001	.030
Clinical Unit Type	26,853	5,370	5.0	4.23	.001	.037
Sex*Group	5,947	5,947	1.0	4.68	.031	.008
Prior electronic clin doc system exp.	11,690	11,690	1.0	9.20	.003	.016
Error	708,761	1270	558			
10) ***Nurse-Assessed Quality of Patient Care on Unit (QoC)***						
Group	6.96	6.96	1.0	4.57	.033	.008
Education	7.62	3.81	2.0	2.50	.083	.009

Education Outside of USA*Group	16.5	16.5	1.0	10.8	.001	.019
Clinical Ladder	12.3	6.17	2.0	4.05	.018	.015
Shift	14.6	7.32	2.0	4.81	.009	.017
Shift*Group	7.38	3.69	2.0	2.42	.090	.009
Clinical Unit Type	48.6	9.72	5.0	6.38	<.001	.055
Clinical Unit Type*Group	16.6	3.33	5.0	2.19	.054	.020
Ethnicity*Group	5.72	5.72	1.0	3.76	.053	.007
Race*Group	18.5	9.25	2.0	6.07	.002	.022
Error	835	1.52	549			

df = Degrees of freedom

F = F distribution

p = Final Model Significance *(p = 0.1 or less)*

Table 4.27

Estimated Marginal Means and Pairwise Comparisons for Essentials of Magnetism II (EOM II)

Independent Sample

		Time 1				Time 2			
Independent Variable	Independent Variable Level	*M*	*SE*	*CI LL*	*CI UL*	*M*	*SE*	*CI LL*	*CI UL*
1) *Nurse Physician Relationships (RNMD)*									
Education*Group	Diploma and Associate	47.14	1.85	43.51	50.78	38.57	3.60	31.51	45.63
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	43.82_{b}	1.01	41.84	45.80				
Clinical Unit Type	Medical Unit	44.84_{b}	1.06	42.76	46.92				
Clinical Unit Type	Surgical Unit	43.83_{b}	1.00	41.87	45.80				
Clinical Unit Type	Intermediate Care	45.02_{ab}	1.22	42.63	47.41				
Clinical Unit Type	Intensive Care Unit	47.61_{a}	0.96	45.74	49.49				
Clinical Unit Type	Women's Health	40.31_{c}	1.41	37.55	43.08				
2) *Support for Education (SuppED)*									
Years HUP Tenure_Coded	3 years or less	12.50_{a}	0.15	12.21	12.78				
Years HUP Tenure_Coded	3+ to 5 years	11.91_{b}	0.19	11.53	12.29				
Years HUP Tenure_Coded	5+ to 10 years	11.95_{abc}	0.21	11.54	12.37				
Years HUP Tenure_Coded	10+ to 15 years	12.57_{ac}	0.33	11.92	13.22				
Years HUP Tenure_Coded	15+ to 20 years	12.64_{abc}	0.45	11.75	13.52				
Years HUP Tenure_Coded	20+ to 30 years	10.99_{b}	0.41	10.19	11.79				
Years HUP Tenure_Coded	30 years or more	10.70_{abc}	0.84	9.06	12.34				
Years HUP Tenure_Coded*Group	10+ to 15 years	13.14	0.53	12.10	14.18	12.00	0.39	11.23	12.77
Years HUP Tenure_Coded*Group	15+ to 20 years	11.88	0.48	10.93	12.82	13.40	0.76	11.92	14.89
Years HUP Tenure_Coded*Group	30 years or more	12.16	1.17	9.85	14.47	9.24	1.18	6.92	11.55

Shift	8, 10 or 12 hour Day Shift	12.20_{a}	0.20	11.81	12.59				
Shift	8, 10 or 12 hour Night Shift	11.74_{b}	0.21	11.32	12.15				
Shift	Rotate > 50% Shifts	11.75_{b}	0.26	11.24	12.25				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	11.84_{ab}	0.25	11.35	12.33				
Clinical Unit Type	Medical Unit	11.71_{ab}	0.25	11.22	12.20				
Clinical Unit Type	Surgical Unit	11.90_{ab}	0.25	11.42	12.38				
Clinical Unit Type	Intermediate Care	12.43_{a}	0.26	11.91	12.95				
Clinical Unit Type	Intensive Care Unit	12.12_{ab}	0.21	11.70	12.54				
Clinical Unit Type	Women's Health	11.38_{b}	0.32	10.75	12.00				
Sex*Group	Male	12.57	0.39	11.81	13.33	11.55	0.39	10.79	12.30
3) *Clinical Autonomy (AUTO)*									
Education	Diploma and Associate	86.72_{a}	2.57	81.67	91.77				
Education	Bachelor	80.88_{b}	0.69	79.52	82.24				
Education	Master and Doctorate	78.38_{b}	1.38	75.66	81.09				
Clinical Ladder*Group	Level 1	78.96	2.07	74.90	83.03	84.84	1.52	81.86	87.82
Clinical Ladder*Group	Levels 3 & 4	82.81	1.92	79.05	86.58	83.53	2.28	79.05	88.01
Shift	8, 10 or 12 hour Day Shift	84.64_{a}	1.18	82.33	86.95				
Shift	8, 10 or 12 hour Night Shift	79.16_{b}	1.27	76.67	81.65				
Shift	Rotate > 50% Shifts	82.18_{ab}	1.45	79.33	85.03				
Prior electronic clin doc system exp.	Yes	82.89_{a}	1.21	80.51	85.26				
Prior electronic clin doc system exp.	No	81.10_{b}	1.14	78.85	83.34				
4) *Control Over Nursing Practice (CNP)*									
Education	Diploma and Associate	81.11_{ab}	2.46	76.27	85.94				
Education	Bachelor	81.02_{a}	1.08	78.91	83.14				
Education	Master and Doctorate	77.94_{b}	1.54	74.92	80.96				
Education Outside of USA	No	78.74_{a}	1.21	76.36	81.12				

Education Outside of USA	Yes	81.31_{b}	1.61	78.14	84.47				
Clinical Ladder	Level 1	81.77_{a}	1.60	78.61	84.92				
Clinical Ladder	Level 2	78.85_{b}	1.32	76.26	81.44				
Clinical Ladder	Levels 3 & 4	79.45_{ab}	1.56	76.39	82.51				
Clinical Ladder*Group	Level 1	78.80	2.25	74.38	83.22	84.74	1.88	81.05	88.43
Shift	8, 10 or 12 hour Day Shift	81.59_{a}	1.32	78.99	84.19				
Shift	8, 10 or 12 hour Night Shift	77.86_{b}	1.37	75.18	80.54				
Shift	Rotate > 50% Shifts	80.62_{ab}	1.61	77.46	83.78				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	79.19_{ab}	1.57	76.11	82.27				
Clinical Unit Type	Medical Unit	81.32_{ab}	1.59	78.19	84.45				
Clinical Unit Type	Surgical Unit	77.53_{a}	1.55	74.49	80.57				
Clinical Unit Type	Intermediate Care	82.29_{b}	1.82	78.72	85.85				
Clinical Unit Type	Intensive Care Unit	82.17_{b}	1.39	79.43	84.89				
Clinical Unit Type	Women's Health	77.65_{ab}	2.06	73.60	81.70				
Sex*Group	Female	76.61	1.29	74.07	79.15	81.82	1.37	79.12	84.51
Prior electronic clin doc system exp.	Yes	81.85_{a}	1.38	79.14	84.57				
Prior electronic clin doc system exp.	No	78.20_{b}	1.27	75.69	80.70				
5) *Perception that Staffing is Adequate (STAFF)*									
Clinical Ladder	Level 1	17.97_{a}	0.32	17.34	18.60				
Clinical Ladder	Level 2	17.21_{b}	0.25	16.72	17.70				
Clinical Ladder	Levels 3 & 4	17.67_{ab}	0.36	16.97	18.37				
Shift	8, 10 or 12 hour Day Shift	18.03_{a}	0.27	17.51	18.56				
Shift	8, 10 or 12 hour Night Shift	17.45_{b}	0.28	16.89	18.00				
Shift	Rotate > 50% Shifts	17.37_{b}	0.35	16.69	18.05				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	17.35_{bc}	0.34	16.68	18.01				
Clinical Unit Type	Medical Unit	17.36_{bc}	0.34	16.69	18.02				

Clinical Unit Type	Surgical Unit	17.48_{bc}	0.32	16.85	18.10				
Clinical Unit Type	Intermediate Care	18.40_{c}	0.40	17.61	19.19				
Clinical Unit Type	Intensive Care Unit	18.43_{ac}	0.30	17.83	19.02				
Clinical Unit Type	Women's Health	16.70_{b}	0.47	15.77	17.62				
Race*Group	Black or African American	18.19	0.47	17.27	19.10	16.66	0.50	15.67	17.65
6) ***Working with Clinically Competent Peers (CCP)***									
Education Outside of USA	No	12.81_{a}	0.16	12.49	13.12				
Education Outside of USA	Yes	13.23_{b}	0.24	12.76	13.69				
Clinical Ladder	Level 1	13.30_{a}	0.22	12.87	13.74				
Clinical Ladder	Level 2	12.74_{b}	0.17	12.42	13.07				
Clinical Ladder	Levels 3 & 4	13.00_{ab}	0.23	12.54	13.46				
Clinical Ladder*Group	Level 2	13.04	0.23	12.59	13.48	12.45	0.22	12.02	12.89
Clinical Ladder*Group	Levels 3 & 4	13.40	0.31	12.80	14.00	12.60	0.34	11.93	13.26
Sex*Group	Female	12.80	0.18	12.44	13.16	13.24	0.18	12.88	13.59
Sex*Group	Male	13.63	0.36	12.92	14.33	12.40	0.36	11.69	13.10
Race*Group	Black or African American	13.49	0.32	12.86	14.13	12.43	0.34	11.77	13.10
Prior electronic clin doc system exp.	Yes	13.19_{a}	0.19	12.82	13.56				
Prior electronic clin doc system exp.	No	12.84_{b}	0.17	12.50	13.18				
7) ***Nurse Manager Support Index (NMS)***									
Total Years Experience_Coded	3 years or less	38.37_{a}	0.58	37.24	39.50				
Total Years Experience_Coded	3+ to 5 years	35.18_{b}	0.68	33.85	36.50				
Total Years Experience_Coded	5+ to 10 years	37.99_{a}	0.78	36.46	39.52				
Total Years Experience_Coded	10+ to 15 years	37.26_{ab}	1.03	35.22	39.29				
Total Years Experience_Coded	15+ to 20 years	38.69_{a}	1.06	36.60	40.78				
Total Years Experience_Coded	20+ to 30 years	37.75_{ab}	1.21	35.36	40.13				
Total Years Experience_Coded	30 years or more	38.66_{ab}	1.72	35.28	42.05				
Total Years	20+ to 30 years	35.25	1.79	31.73	38.76	40.25	1.55	37.20	43.29

Experience_Coded*Group									
Total Years	30 years or more	43.69	2.14	39.49	47.90	33.63	2.60	28.53	38.74
Experience_Coded*Group									
Shift	8, 10 or 12 hour Day Shift	38.84_{a}	0.59	37.67	40.00				
Shift	8, 10 or 12 hour Night Shift	36.68_{b}	0.64	35.42	37.94				
Shift	Rotate > 50% Shifts	37.58_{ab}	0.80	36.00	39.15				
Sex	Female	36.84_{a}	0.42	36.02	37.65				
Sex	Male	38.56_{b}	0.92	36.76	40.36				
Prior electronic clin doc system exp.	Yes	38.45_{a}	0.64	37.20	39.70				
Prior electronic clin doc system exp.	No	36.95_{b}	0.58	35.80	38.09				
8) *Patient-Centered Values (PCV)*									
Education	Diploma and Associate	35.93_{a}	1.02	33.93	37.93				
Education	Bachelor	34.81_{a}	0.45	33.93	35.69				
Education	Master and Doctorate	33.19_{b}	0.64	31.93	34.45				
Education Outside of USA	No	33.72_{a}	0.50	32.74	34.71				
Education Outside of USA	Yes	35.56_{b}	0.67	34.24	36.88				
Clinical Ladder	Level 1	35.60_{a}	0.67	34.29	36.92				
Clinical Ladder	Level 2	34.21_{b}	0.55	33.13	35.28				
Clinical Ladder	Levels 3 & 4	34.12_{ab}	0.65	32.85	35.39				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	33.92_{b}	0.66	32.63	35.20				
Clinical Unit Type	Medical Unit	35.15_{ab}	0.66	33.85	36.45				
Clinical Unit Type	Surgical Unit	34.02_{b}	0.65	32.74	35.30				
Clinical Unit Type	Intermediate Care	36.31_{a}	0.75	34.83	37.79				
Clinical Unit Type	Intensive Care Unit	35.20_{ab}	0.58	34.06	36.33				
Clinical Unit Type	Women's Health	33.26_{b}	0.86	31.57	34.94				
Clinical Unit Type*Group	Mixed Med-Surg / Outpatient Observation	33.01	0.87	31.30	34.72	34.83	0.83	33.20	36.45

Sex*Group	Female	33.80	0.51	32.80	34.81	35.08	0.52	34.06	36.10
Prior electronic clin doc system exp.	Yes	35.22_a	0.57	34.09	36.35				
Prior electronic clin doc system exp.	No	34.07_b	0.53	33.02	35.10				
9) ***Professional Practice Satisfaction (PPS) / Total EOM II Score***									
Education	Diploma and Associate	333_a	8.21	317	349				
Education	Bachelor	323_a	3.58	316	330				
Education	Master and Doctorate	313_b	5.12	302	323				
Clinical Ladder	Level 1	329a	5.35	319	340				
Clinical Ladder	Level 2	319_b	4.39	311	328				
Clinical Ladder	Levels 3 & 4	320_{ab}	5.19	310	331				
Clinical Ladder*Group	Level 1	321	7.50	306	335	338	6.26	325	350
Shift	8, 10 or 12 hour Day Shift	331_a	4.41	322	339				
Shift	8, 10 or 12 hour Night Shift	317_b	4.55	308	326				
Shift	Rotate > 50% Shifts	321_b	5.36	311	332				
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	319_{ab}	5.22	309	330				
Clinical Unit Type	Medical Unit	325_{ab}	5.31	315	336				
Clinical Unit Type	Surgical Unit	317_a	5.16	307	327				
Clinical Unit Type	Intermediate Care	333_b	6.05	321	345				
Clinical Unit Type	Intensive Care Unit	332_b	4.63	323	341				
Clinical Unit Type	Women's Health	311_a	6.86	298	325				
Sex*Group	Female	312	4.31	304	321	328	4.57	319	337
Prior electronic clin doc system exp.	Yes	328_a	4.61	319	337				
Prior electronic clin doc system exp.	No	318_b	4.25	310	326				
10) ***Nurse-Assessed Quality of Patient Care on Unit (QoC)***									
Education	Diploma and Associate	8.99_a	0.31	8.39	9.59				
Education	Bachelor	8.57_a	0.18	8.22	8.93				

Education	Master and Doctorate	8.33_{b}	0.22	7.89	8.77				
Education Outside of USA*Group	Yes	8.06	0.30	7.48	8.64	9.35	0.33	8.71	10.00
Clinical Ladder	Level 1	8.88_{a}	0.23	8.43	9.32				
Clinical Ladder	Level 2	8.48_{b}	0.19	8.10	8.85				
Clinical Ladder	Levels 3 & 4	8.54_{ab}	0.22	8.10	8.97				
Shift	8, 10 or 12 hour Day Shift	8.86_{a}	0.20	8.46	9.25				
Shift	8, 10 or 12 hour Night Shift	8.58_{b}	0.20	8.19	8.97				
Shift	Rotate > 50% Shifts	8.45_{b}	0.22	8.01	8.89				
Shift*Group	Rotate > 50% Shifts	7.89	0.30	7.30	8.47	9.02	0.31	8.40	9.63
Clinical Unit Type	Mixed Med-Surg / Outpatient Observation	8.25_{a}	0.22	7.82	8.68				
Clinical Unit Type	Medical Unit	8.71_{ab}	0.22	8.28	9.14				
Clinical Unit Type	Surgical Unit	8.52_{a}	0.22	8.09	8.95				
Clinical Unit Type	Intermediate Care	8.69_{ab}	0.24	8.21	9.16				
Clinical Unit Type	Intensive Care Unit	9.14_{b}	0.21	8.73	9.55				
Clinical Unit Type	Women's Health	8.48_{a}	0.26	7.96	9.00				
Clinical Unit Type*Group	Mixed Med-Surg / Outpatient Observation	7.71	0.28	7.16	8.26	8.79	0.32	8.16	9.42
Clinical Unit Type*Group	Surgical Unit	7.84	0.30	7.25	8.43	9.19	0.29	8.62	9.76
Ethnicity*Group	Hispanic or Latino	8.00	0.39	7.24	8.76	9.32	0.49	8.35	10.29
Race*Group	White or Caucasian	7.83	0.25	7.34	8.32	9.14	0.28	8.58	9.69
Race*Group	Black or African American	8.32	0.29	7.76	8.89	9.07	0.34	8.41	9.73

M = Mean

SE = Standard error

CI LL = Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Table 4.28

Parameter Estimates for Final Univariate GLM Models for Essentials of Magnetism (EOM II)

Independent Sample

Continuous Independent Variable	Phase	*B*	Std. Error	*p**	*CI LL*	*CI UL*	Partial Eta Squared
Clinical Autonomy (AUTO)							
Years HUP Tenure		-.205	.106	**.054**	-.413	.003	.007
Patient-Centered Cultural Values (PCV)							
Hours Per Pay Period		.019	.011	**.093**	-.003	.041	.005
Hours Per Pay Period*Group	1	-.039	.018	**.028**	-.074	-.004	.009
Hours Per Pay Period*Group	2	0					

B = Beta coefficient

p = Final Model Significance *(p = 0.1 or less)*

CI LL= Confidence Interval Lower Limit

CI UL = Confidence Interval Upper Limit

Summary of Variable Effect Size and Frequency in GLM Regression Models

Across all 30 regression models, partial eta squared effect sizes for all variables were generally small and ranged from .000 to .109. *Clinical Unit Type* and *Shift* partial eta squared effect sizes were generally the largest among all the independent explanatory variables. For the partial eta squared values between .06 and .109, *Clinical Unit Type* or *Clinical Unit Type*Time* represented 78% of the variables in the range. *Shift* contributed an additional 22% of partial eta squared values in the same range. For the univariate GLM models, Adjusted R Squared values ranged from 0.53 for *HIT Depersonalizes Care* to 0.198 for *General Advantages of HIT*.

Table 4.29 summarizes the frequency of independent variable inclusion in I-HIT and EOM II final models. *Clinical Unit Type* (80%), *Shift* (63%), and *Clinical Ladder* (50%) were the most frequently occurring main-effect variables, followed by *Race* and *Education Outside of the United States* (both 33%). The most frequently occurring interaction variables were *Clinical Unit Type*Time* (53.3%), *Race*Time* (26.7%) and *Shift*Time* (23.3%).

Race (90%) was the most frequently occurring I-HIT main-effect variable, followed by *Clinical Unit Type* (70%). *Clinical Unit Type* and *Shift* (85%) were the most frequently occurring EOM II main-effect variables. The most frequently occurring I-HIT interaction variables were *Clinical Unit Type*Time* (100%), and *Education outside the USA*Time* (60%). The most frequently occurring EOM II interaction variable was *Clinical Ladder*Time* (40%).

The *Shift* and *Race* main-effect variables varied the most between the EOM II and I-HIT. *Race* appeared in 90% of the I-HIT models, but only 5% of EOM II models. Similarly, *Shift* appeared in 85% of the EOM II models, but only in 20% of the I-HIT models. *Clinical Unit*Time* appeared in 100% of the I-HIT models and 30% of the EOM II models, marking the largest interaction variable difference.

Table 4.29

Summary of Independent Variable Frequency for Inclusion in Final GLM Regression Models

Independent Variable	Paired EOM *f*	Paired I-HIT *f*	IND EOM *f*	IND I-HIT *f*	Total *f*
Education			5	2	7
Education*Time			1		1
Education Outside of USA	1	4	3	2	10
Education Outside of USA*Time			3	2	5
Total Years Experience_Continuous	1				1
Total Years Experience_Continuous*Time					
Total Years Experience_Coded		1	1		2
Total Years Experience_Coded*Time	2		1		3
Years HUP Tenure_Continuous			1		1
Years HUP Tenure_Continuous*Time					
Years HUP Tenure_Coded	1	1	1		3
Years HUP Tenure_Coded*Time		2	1		3
Clinical Ladder	5	1	6	3	15
Clinical Ladder*Time	3		5	1	9
Shift	9	1	8	1	19
Shift*Time	2	1	1	3	7
Clinical Unit Type	9	3	8	4	24
Clinical Unit Type*Time	4	5	2	5	16
Age	1				1
Age*Time					
Sex			1		1
Sex*Time			6		6
Ethnicity		1		2	3
Ethnicity*Time		1	1	2	4
Race	1	5		4	10
Race*Time	2	3	3		8
Hours per pay period	1	1			2
Hours per pay period*Time	1	2	1	1	5
Prior electronic clin doc system exp.			6	2	8
Prior electronic clin doc system exp*Time	1				1

Time = "Time" and/or "Group"; *f* = Frequency

Pairwise Comparisons and Estimated Marginal Means

Between-Subjects: Main Effect Variables

For the independent variable *Clinical Unit Type*, Medical was the I-HIT survey response with the highest estimated marginal mean (EMM) 85.7% of the time. Women's Health had the lowest EMM 60% of the time. For the EOM II, Intermediate Care was the response with the highest, occurring 73.3% of the time; Intensive Care carried the highest EMM the remaining 26.7% of the time.

For the independent variable *Shift*, 8, 10 or 12 hour Nights was the most often the lowest EMM with a frequency of 87.5%. The 8, 10 or 12 hour Day Shift response occurred most often as the highest EMM, with a frequency of 77.7.

For all I-HIT and EOM II (paired and independent) subscales, *Clinical Ladder,* Level 1, had the highest EMM. For the I-HIT, Level 3 & 4 had the lowest EMM most frequently (*f*=3); for the EOM II, Level 2 (*f*=8) was most frequently the lowest EMM.

Race category White was the response with the lowest EMM 90% of the time. The only exception was *HIT Depersonalizes Care* on the paired I-HIT. Across all subscales the survey response Black or African Americans had the highest EMM (*f* =7) occurring 70% of the time.

Response choice "Yes" had the highest EMM for question "*Prior to working at HUP, have you worked with an electronic nursing clinical documentation system*" 100% of the time. This suggests that prior experience was aligned with a generally favorable perception of aspects of knowledge work and the practice environment. Of note, *Prior Electronic Nursing Clinical Documentation System Experience* was not significant for any paired sample.

The independent variable *Education* only appeared in independent sample final models. For the EOM sample, diploma and associate degree has the highest estimated mean 80% of the time (*f*=5). For the I-HIT sample bachelor's had the highest EMM in both occurrences (*f*=2).

Across seven subscales for the I-HIT (*f*=2) and EOM II (*f*=5), master's and doctorate had the lowest EMMs.

Neither *Age*, nor *Age*Time* served to significantly explain outcome variable variance. *Ag*e only appeared in *Nurse-Assessed Usual Quality of Care on the Unit* where a one year increase in nurse age was associated with a very small increase (B *=.016)* in the dependent outcome. Similarly, *Total Years Experience* and *Institutional Tenure* were present with surprisingly low frequency (3 each). *Hours Per Pay and Hours Per Pay*Time* were included nine times in final model and associated with small increases in dependent outcome scores.

Within-Subjects Effects: Interaction Variables

For Within-Subjects interaction variables, "Time" is used here to connote interactions for both the paired and independent samples. Interaction variables appeared 29 times in final Repeated Measures (15 EOM II and 14 I-HIT), and 38 times for the Univariate (24 EOM II and 14 I-HIT). These changes over time, from pre- to post-implementation, are the most salient to this study.

The EMM post-implementation score changed 29 times for the independent variable *Clinical Unit Type*Time*. ICU (*f*=6) and Women's Health (*f*=3) always declined. Mixed Medical-Surgical increased 83.3% and Surgical 66.6%, each appeared 6 times. Medical increased 75% of the time, and occurred 4 times. Intermediate clinical unit type appeared 4 times, and the EMM post-implementation difference increased and decreased twice. It is notable that 22 of the 29 post-implementation differences were associated with I-HIT subscales. Furthermore, 17 of those 22 accounting for 77%, were post-implementation EMM declines, and were in the majority distributed among two subscales: *General Advantages of HIT* (*HITGA*) and *Workflow Implications of HIT* (*HITWF*).

*Shift*Time* appeared in final models much less frequently than the main-effect variable *Shift*. The change in mean subscale scores over time was distributed over all three shifts: Days (*f*=2), Nights *(f*=2), and Rotate >50% of Shifts Worked (*f*=1).

Level 1 appeared 5 times in the EOM and I-HIT surveys for *Clinical Ladder*Time* and the estimated post-implementation mean score increased 4 out of those 5 times. For Clinical Levels 2 and 3 & 4 all the EMM scores decreased for all subscales. For *Race*Time*, the estimated marginal means post-implementation scores were mixed. Whites accounted for five of the 10 post-implementation scores, and increased 60%. All three race categories showed increases and decreases, and the variances did not indicate a strong direction across time.

Summary of Specific Aim 2

- Line graphs of Nurse Staffing (DCHPPD) and Turnover did not demonstrate discernible positive or negative trends across the 14-month study period. DCHPPD and Turnover had very weak, not operationally meaningful, bivariate Pearson's Product Moment and Spearman's rho correlations with I-HIT and EOM II subscales and were not included in regression models.
- Thirteen independent nurse and patient care unit characteristic explanatory variables were tested in simple bivariate regression models and in a sequential backward elimination procedure to determine inclusion in final models. Tables 4.30 through 4.33 summarize variables significant at 0.1 or less in final models.
- In 30 Repeated Measure and Univariate GLM regression models, the main-effect and interaction independent variables that explained the most variance were the following:
    - *Clinical Unit* and *Clinical Unit*Time*
    - *Shift* and *Shift*Time*
    - *Clinical Ladder* and *Clinical Ladder*Time*
    - *Race* and *Race** *Time*
    - *Education Outside of USA*, and to a lesser extent *Education Outside the USA*Time*
- Between-Subjects Main Effect independent variables appeared in final models more often than the Within-Subjects Interaction variables, demonstrating that variance existed between groups prior to the CDSS implementation. This Between-Subjects variance is an important consideration for future CDSS system development and implementation.

- Within-Subjects Interaction variables appeared 29 times in final Repeated Measures and 38 times for the Univariate models. These changes over time, from pre- to post-implementation, are the most salient to this study.
- Clinical Unit Type*Time was the Within-Subjects Interaction variable that explained the greatest amount of variance across both the I-HIT and EOM.
- *Clinical Unit Type, Clinical Unit Type*Time, Shift* and *Shift*Time* the independent variables that occurred with the greatest frequency in final models and also had the largest partial eta squared effect sizes.
- Experience variables (*Total Years Experience* and *Institutional (HUP) Tenure* appeared infrequently in final models and did not contribute to explaining significant variance.
- Similarly, *Age* did not factor significantly into explaining subscale variance and appeared in only one final model with a small beta coefficient.
- *Hours Per Pay* and *Hours Per Pay*Time* appeared in several final models, but consistently with small beta coefficients.

Table 4.30

Independent Variables in Final Repeated Measures GLM Models (p = 0.1 or less) for I-HIT Paired Sample

Independent Variable	HIT GA	HIT WF	HIT SCT	HIT SIT	HIT Depersonalize
Time	<.001	<.001		.051	
Education					
Education*Time					
Education Outside USA	.037	.050	.006	.016	
Education Outside USA*Time					
Years Total Experience_Continuous					
Years Total Experience_Continuous*Time					
Years Total Experience_Coded				.051	
Years Total Experience_Coded*Time					
Years HUP Tenure_ Continuous					
Years HUP Tenure_Continuous*Time					
Years HUP Tenure _Coded	.026				
Years HUP Tenure _Coded*Time	.066		.046		
Clinical Ladder		.010			
Clinical Ladder*Time					
Shift			.018		
Shift*Time			.068		
Clinical Unit Type	<.001	.010	.029		
Clinical Unit Type*Time	<.001	.000	.008	<.001	.029
Age					
Age*Time					
Sex					
Sex*Time					
Ethnicity					.091
Ethnicity*Time					.031
Race	<.001	.000	.003	<.001	.022
Race*Time		.030	.053		.016
Hours Per Pay Period			.069		
Hours Per Pay Period*Time	.040				.009
Prior electronic clinical documentation system experience					
Prior electronic clinical documentation system experience*Time					

Table 4.31

Independent Variables in Final Univariate GLM Models (p = 0.1 or less) for I-HIT Independent Sample

Independent Variable	HIT GA	HIT WF	HIT SCT	HIT SIT	HIT Depersonalize
Group	<.001				
Education			.021	.049	
Education*Group					
Education Outside USA	.089			.011	
Education Outside USA*Group			.027		.015
Years Total Experience_Continuous					
Years Total Experience_Continuous*Group					
Years Total Experience_Coded					
Years Total Experience_Coded*Group					
Years HUP Tenure_ Continuous					
Years HUP Tenure_Continuous*Group					
Years HUP Tenure _Coded					
Years HUP Tenure _Coded*Group					
Clinical Ladder	.006	.002	.093		
Clinical Ladder*Group				.046	
Shift			.088		
Shift*Group			.021	.020	.010
Clinical Unit Type	<.001	<.001	.001	<.001	
Clinical Unit Type*Group	<.001	<.001	.009	.020	.007
Age					
Age*Group					
Sex					
Sex*Group					
Ethnicity				.070	.030
Ethnicity*Group		.049		.026	
Race	.001	<.001	.001	.001	
Race*Group					
Hours Per Pay Period					
Hours Per Pay Period*Group					.053
Prior electronic clinical documentation system experience	.007	.003			
Prior electronic clinical documentation system experience*Group					

Table 4.32

Independent Variables in Final Repeated Measures GLM Models (p = 0.1 or less) for EOM II Paired Sample

Independent Variable	RNMD	SuppED	Auto	CNP	Staff	CCP	NMS	PCV	PPS	QoC
Time			.001	.001						
Education										
Education*Time										
Education Outside USA	.020									
Education Outside USA*Time										
Years Total Experience_Continuous							.001			
Years Total Experience_Continuous*Time										
Years Total Experience_Coded										
Years Total Experience_Coded*Time			.084					.014		
Years HUP Tenure_Continuous										
Years HUP Tenure_Continuous*Time										
Years HUP Tenure _Coded	.074									
Years HUP Tenure _Coded*Time										

Clinical Ladder	.016			.049		.026		.003	.062	
Clinical Ladder*Time					.002		.067	.044		
Shift		.003	<.001	<.001	.048	.066	<.001	.004	<.001	<.001
Shift*Time						.017	.066			
Clinical Unit Type	<.001	.001		.067	<.001	.028	.025	.010	.007	.001
Clinical Unit Type*Time					.001		.043	.071		.019
Age										.015
Age*Time										
Sex										
Sex*Time										
Ethnicity										
Ethnicity *Time										
Race	.060									
Race*Time		.035							.026	
Hours Per Pay Period								.044		
Hours Per Pay Period*Time						.040				
Prior electronic clinical documentation system experience*Time							<.001			

Table 4.33

Independent Variables in Final Univariate GLM Models (p = 0.1 or less) for EOM II Independent Sample

Independent Variable	RNMD	SuppED	Auto	CNP	Staff	CCP	NMS	PCV	PPS	QoC
Group			.047					.085		.033
Education			.010	.082				.007	.022	.083
Education*Group	.095									
Education Outside USA				.068		.070		.002		
Education Outside USA*Group				.039					.083	.001
Years Total Experience_Continuous										
Years Total Experience_Continuous *Group										
Years Total Experience_Coded							.001			
Years Total Experience_Coded*Group							.009			
Years HUP Tenure_Continuous			.054							
Years HUP Tenure_Continuous*Group										
Years HUP Tenure _Coded		<.001								
Years HUP Tenure _Coded*Group		.063								

Clinical Ladder				.067	.019	.010		.027	.064	.018
Clinical Ladder*Group			.079	.039		.071		.053	.061	
Shift		.005	<.001	.002	.022		.002	.070	<.001	.009
Shift*Group										.090
Clinical Unit Type	<.001	.018	.063	.004	<.001			.002	.001	<.001
Clinical Unit Type*Group								.091		.054
Age										
Age*Group										
Sex							.058			
Sex*Group		.044		.028	.044	.001		.080	.031	
Ethnicity										
Ethnicity *Group										.053
Race										
Race*Group					.056	.079				.002
Hours Per Pay Period										
Hours Per Pay Period*Group								.028		
Prior electronic clinical documentation system experience			.070	<.001		.017	.005	.004	.003	

CHAPTER 5: DISCUSSION

Introduction

The purpose of this study was to examine the impact of a CDSS implementation on nurses' perception of their ability to perform aspects of knowledge work and on the nursing practice environment. This study also evaluated the extent to which nurse attributes and clinical unit characteristics explained variance in the outcome measures. The following provides a discussion of the findings and limitations of this study, and offers recommendations for future research.

As described in *Chapter 3*, findings from this study were derived from a paired and an independent sample. The paired sample completed both the pre- and post-implementation surveys. The independent sample completed either the pre- or post-implementation survey, but not both. The study used a pre-post quasi-experimental design and employed *t*-tests for independent and paired groups, and univariate GLM regression models. Participants were comprised of a convenience sample of 1,045 direct care Registered Nurses (RNs) from an acute care, academic medical center located in Southeastern Pennsylvania. Nurses included in the independent sample, because they had no previous exposure to the questions, were exempt from survey recall bias. Sample sizes for both the paired (n=458) and independent (n=587) surveys were large, subjects were recruited from the same hospital, and data were subjected to the same analysis. As a result, the independent sample served to replicate, and potentially validate, the paired sample.

Summary of Study Findings

The I-HIT post CDSS implementation scores decreased across all subscales, indicating that nurses perceived a reduced ability to perform aspects of their knowledge work. Results

indicated that nurses perceived less access to patient information, a diminished ability to prepare for their daily caseloads, less information to facilitate independent decisions, a diminished ability to communicate with colleagues, and reduced practice efficiencies. Nurses also did not perceive that the CDSS improved their clinical workflow, which includes movements though time and space and non-linear cognitions.

The EOM II *Clinical Autonomy* subscale measured essentially no change in the environment's support of nurses' independent decision-making and freedom to act. The *Control Over Nursing Practice* subscale found only a small improvement in nurses' perceptions about their effectiveness in securing a work environment that supports deliberative and autonomous practice. The *Working with Clinically Competent Peers, Patient-Centered Values, Professional Practice Satisfaction, and Nurse-Assessed Quality of Care* subscales remained essentially unchanged. Overall, the practice environment was perceived as providing the same level of support for nurses' knowledge work, with some slight improvements and no statistically significant declines from pre- to post-testing time periods.

This study found independent variable differences such as *Clinical Unit Type, Shift*, *Clinical Ladder*, and whether or not *Education was Obtained Outside the USA*, explained more variance in the subscale outcomes than expected. Conversely, some nurse attributes such as *Age*, *Years Experience, Institutional Tenure,* and *Education Level* explained less variance.

Paired and Independent Sample Differences

The paired and independent samples matched, in terms of statistical significance, for four out the five I-HIT subscales. The EOM II paired and independent samples, however, were consistent for only one of the ten subscales; *Working with Clinically Competent Peers* was found significant in the independent sample, but not the paired. Several explanations may account for the EOM II sample discrepancies. First, the repeated measures paired difference test compared

measures within, rather than across subjects and generally has greater power at detecting differences (Cohen, 1992).

Second, the independent and paired sample sizes were quite large, and under these circumstances, it is neither unexpected nor necessarily meaningful to find random and small differences between subscales (Cohen, 1992). This is true even when the independent and paired samples are designed to replicate one another. Third, the independent and paired samples, despite having originated from the same study, may have represented different populations. An analysis of the independent post-implementation sample found that it contained nearly twice as many novice nurses (28.4%), than did the pre-implementation independent sample (15.4%). New nurses may have simply not had enough experience to formulate opinions about the clinical environment, or the impact of the CDSS on practice. Research has shown that when transitioning into practice, new graduate nurses focus on developing skills such as delegation, task prioritization, and patient care (Kramer et al., 2012). The independent subjects may have also been about to transition out of the organization, or considered the survey subordinate to some other priority. Those who completed only the first survey may have considered the questions too risky, despite assurances of confidentiality, to take the survey a second time. This would have been especially true for nurses who held unfavorable opinions about the newly implemented CDSS.

Discussion and Implications of Main Findings

Studies and literature written in response to recent and unprecedented rates of EHR and CDSS implementations (Gabriel & Furukawa, 2014; Jones & Furukawa, 2014), reveal tensions, anticipated in *Chapters 1 and 2*, between practice and process (Head, 2013). On the one hand, clinicians are expressing desire to retain autonomy of practice and are concerned about the devaluation of their expertise and decision-making (Ash, Sittig, Campbell, Guappone, & Dykstra,

2006; Esmaeilzadeh, Sambasivan, Kumar, & Nezakati, 2015; Walter & Lopez, 2008; Weber, 2007). On the other hand, CDSSs are premised on standardizing care processes and replacing subjective clinical judgments with databases of centrally maintained evidence-based clinical practice guidelines (CPGs) (Blumenthal, 2011; Kawamoto, Houlihan, Balas, & Lobach, 2005; Lee, 2014).

The following discussion of this study's results is intended help nurse leaders consider the impact of these themes, as well as the impact of CDSSs on the work preferences and attributes of nurse knowledge workers. The I-HIT is used to isolate the technical proficiency of the CDSS: to collect, share, retrieve, and display information. The EOM II assesses some of the social, psychological, and political implications that CDSSs have on the practice environment, including those related to reengineered work processes and organizational policies.

This study marks a unique contribution to the understudied phenomena of CDSSs and the potentially profound impact on the direction of the nursing profession. To the best of my knowledge, this study is the first to address the practice/process dichotomy, with respect to nurse knowledge workers, at an academic medical center consisting of 95% bachelor's degree or better-prepared nurses, and featuring institutional initiatives designed to encourage expertise. In addition, it is one of the first to investigate an EHR integrated system, the type of CDSS predicted to garner the vast majority of the market share through the year 2022 ("Global CDSS Market Growth CAGR by 2022", 2016; P&S Market Research, 2016).

Specific Aim 1

Nurses' Perceptions of their Ability to Perform Aspects of Knowledge Work and the Practice Environment Post CDSS Implementation

Information and Communication

The *Information Tools to Support Communication Tasks (HITSCT)* and *Information Tools to Support Information Tasks (HITSIT)* subscales evaluated nurses' perceptions about the CDSS' ability to facilitate the exchange of information and communication.

The *HITSCT* subscale significantly decreased .24 for the paired sample only; the independent sample numerically decreased, but only .07, and was not found to be significant (p = .367). The *HITSCT* indicated that nurses' perceived less satisfaction with the system's ability to facilitate communications and collaboration with interdisciplinary colleagues: Item 18*, "My site is utilizing HIT strategies to optimize interdisciplinary communications"* decreased .32 for the paired and .40 for the independent. They also perceived that there was less support derived from communication tools for either patient care or administrative processes. It is notable that despite these declines nurses indicated an increased ability to access tools and applications associated with communication, suggesting adequate training and orientation: Item 24, "*I know how to access the HIT applications/tools available in the EHR*" was, in fact, the only I-HIT item increase for both the paired and independent samples (range $^{+}$0.17 to $^{+}$0.19).

The *Information Tools to Support Information Tasks (HITSIT)* subscales also significantly declined an average of .3 across the paired and independent samples. Item 28, "*Communication of critical events to interdisciplinary colleagues can be done effectively using HIT"* also decreased .41 and .52 for the paired and independent samples respectively. Items 25, 26 and 27 collectively indicated a decrease in nurses' perceptions about the ability to confirm that information was received, interpreted, and acted on in a proper and timely way.

A core competency of CDSSs and their underlying database architecture is their purported ability to coordinate the transfer of information. This includes the ability to search, and retrieve enormous amounts of clinical data efficiently (Rothman, Leonard, & Vigoda, 2012). These advantages were, however, not reflected in the subscales *HITSIT*. For example, Item 29 indicated that nurses found they were less able to use these capacities to address clinical problems effectively.

The *General Advantages of HIT (HITGA)* subscale, which demonstrated significant declines for the paired and independent samples, also evaluated nurses' perceptions about the availability and use of information. *HITGA* Items 3 and 7 indicated that nurses' perceived a decrease in the availability and quality of information required to prepare for their daily caseloads, and perceived less information support at the point of care. Even more interesting, nurses' perceived that the system did not offer information in a way that supplanted the need to find and talk with team members. *HITGA* Item 6, "*The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone,"* decreased .47 for the paired and .23 for the independent.

It is important for nurse leaders and managers to understand that based on these findings CDSSs may challenge nurse knowledge workers' traditional reliance on fluid interactions that occur naturally and in nonlinear ways. Studies report wide variation in the percentage of clinicians' time devoted to verbal communication, ranging from 12% to 60% (Ballermann, Shaw, Mayes, Gibney, & Westbrook, 2011; Cornell, Herrin-Griffith, Keim, & Petschonek, 2010; Tang et al., 1996). Another study reported that, up to 84% of the time, nurses prefer to gather and convey important handoff information directly to colleagues rather than by way of documentation sources (Benham-Hutchins & Effken, 2010). Other researchers have observed that nurses derived information through a multitude of exchanges that "peppered the clinical day:" asking and telling, inquiring and explaining, and sometimes informally employing discipline-specific vernacular and

body language (Coiera, 2000, p. 277). These preferences persist even when information systems are mature and familiar to nurses. Prior research documents that 50% of information was exchanged face-to-face; e-mail and voicemail accounting for a 25% of exchanges; and only 10% of exchanges were made using the EHR (Collins, Bakken, Vawdrey, Coiera, & Currie, 2010; Safran, Sands, & Rind, 1999). Studies have also indicated that 38% of nurses notes generated in EHRs went unread and may explain nurses' preference for verbal over electronic communication (Hripcsak, Vawdrey, Fred, & Bostwick, 2011; Penoyer et al., 2014). Effective and efficient communication is particularly important to nurses as they are responsible for the vast majority of patient documentation, and are charged with being the primary coordinators and communicators of the patient plan of care (Dykes et al., 2007).

At the time of the CDSS implementation, some important clinical disciplines, such as medicine and social work were not included, and the study venue chose to retain some discipline-specific, non-integrated legacy documentation systems. Considering the CDSS implementation was not fully integrated, it is encouraging that the *HITSCT* and *HITSIT* subscale scores remained at $M = 4.35$ and $M = 3.52$, correlating with agreement and slight disagreement respectively, that nurses perceived that the CDSS supported aspects of knowledge work.

The immediate challenge for nurse leaders is to leverage technologies from other industries to render clinical communications more natural and less encumbered. Nurse leaders have already observed that mobile applications and hand-held devices may be used to capitalize and emulate the sense of community found in ubiquitous, and now intuitive, social media applications used pervasively outside of healthcare on tablets and mobile phones (Coopmans & Biddle, 2008; Di Pietro et al., 2008; von Muhlen & Ohno-Machado, 2012).

Clinical Workflow

The I-HIT *Workflow Implications of HIT (HITWF)* subscale fell from $M = 4.46$ to $M = 3.85$ ($p < .001$) for the paired sample and from $M = 4.40$ to $M = 4.04$ ($p < .001$) for the independent, marking the I-HIT's largest subscale decline. Overall, nurse knowledge workers did not perceive that the CDSS improved the display of information, the ability to track patients, or the ability to collaborate during the flow of their practice.

CDSS data input. While most industries are entering their fifth decade of using and optimizing transaction-processing systems, clinical environments, spurred by the HITECH Act, are just beginning to structure work processes in a transactional way. This involves transitioning away from the limitations of paper-based documentation systems. For example, of the over 1.2 billion medical records created in the U.S. in 2009, 700 million were estimated to contain valuable patient information trapped in unstructured formats (American Medical Association, 2012). IBM estimated that 80% of all clinical information is gathered and stored in ways, primarily paper, that defy effective and timely distillation (Sheridan, 2015). Moreover, research has indicated that paper-based records are often incomplete, difficult to find, and challenging to read and extract meaningful information from (Smith et al., 2005). These constraints inhibit the efficient exchange of data between hospital departments; post-acute healthcare network entities, such as rehabilitation facilities and homecare; and across vast networks of providers. In fact, Dykes et al. (2014) reported that the implementation and use of patient-centered longitudinal care plans, intended to coordinate care across the full continuum of care, remains more "vision than reality" and the current state is suboptimal.

The HITECH Act's EHR mandate is an incremental step, intended to leverage data in a myriad of transformational ways, including empowering patients with information so that they may actively manage aspects of their own care and prevention (Friedberg et al., 2013). Less obvious initiatives have to do with knowledge creation, for example, furnishing data warehouses

with the fine-grained clinical data necessary to stimulate the evolution of precision medicine and next generation clinical software applications (Quinn, 2016). The infrastructure to collect medical information is now reaching into clinical environments, and the ability to evaluate data is well on the road to maturity. Nurses consequently, in the midst of their clinical workflow may be charged with supplying information to CDSSs and EHRs, which anticipate and answer initiatives beyond their immediate clinical purview--sometimes far beyond.

Interpreting and entering clinical events accurately, via mouse and keyboard, extemporaneous with the delivery of care is a significant workflow change and has been identified as a barrier to clinicians' acceptance of CDSS and EHR systems (Friedberg et al., 2013). Clinicians are obliged to enter data reflective of their interventions and clinical observations in rigorous proximity to their occurrence. CDSSs are particularly uncompromising in this respect, as data latency inhibits the system's ability to model patients, and make accurate inferences about treatments and interventions (Campion Jr. et al., 2010; Campion, Waitman, Lorenzi, May, & Gadd, 2011). Timely data entry and documentation is also a priority because CDSSs are intended to maintain detailed patient profiles and on demand narratives of patient care episodes to function as a hub; synchronizing the efforts of the immediate and extended care teams (Weir et al., 2011). Clinicians, as a consequence are not afforded the clinical workflow option that paper based systems may have allowed--to "batch process" documentation at convenient times during or after their shift (Collins et al., 2010).

CDSSs arrange graphical user interfaces in ways that have been established by informatics professionals and used in other industries for decades (Horsky et al., 2012). These include checkboxes, drop-down lists, text, and memo-fields. They also employ standardized lists and assessment items, which improve legibility, reduce typing, and promote clinically correct and precise language (Ward, Vartak, Schwichtenberg, & Wakefield, 2011). These screen design principles, however, may over emphasize structure and "...may not be suitable for highly

interruptive use contexts," (Ash, Berg, & Coiera, 2004, p. 106). Many clinicians have reported that they are spending increased time in front of screens and that much of that time includes clicking to satisfy "... onerous billing and administrative requirements" (Pollock, 2014, p. 1). An *American Journal of Emergency Medicine* study documented that emergency physicians spend 43% of their time entering data into computers, and that during a typical 10 hour shift would click a mouse almost 4,000 times (Hill, Sears, & Melanson, 2013).

I-HIT Items 7, 8, 10 and 15 indicated that nurses' were dissatisfied with "*The way… data and information were displayed…"* this graphical user interface concern has been cited by prior research as inhibiting data-entry and workflow (Miller et al., 2015; Sockolow, Rogers, Bowles, Hand, & George, 2014). I-HIT Item 1, "*Applications/tools have decreased the time I need for end of shift report*" may also have been affected by suboptimal displays and recorded one of the largest I-HIT paired and independent sample declines. Studies have shown mixed results with respect to the CDSSs' ability to expedite data entry (Bright et al., 2012; Poissant, Pereira, Tamblyn, & Kawasumi, 2005), and also the ability of the CDSS to enrich the content of documentation (Collins, Fred, Wilcox, & Vawdrey, 2012; Wang, Yu, & Hailey, 2015). This is an important consideration as the way patient data is "fed into" systems has been shown to influence the way clinicians' think about and remember patient interactions (Dunn Lopez et al., 2016; Embi et al., 2013; Hoff, 2011, p. 343; Varpio et al., 2015a; Varpio et al., 2015b).

The challenges that data entry imposes on clinical workflow may be mitigated with optical recognition systems, voice recognition, and refinements to CDSS graphical user interfaces (Dela Cruz et al., 2014; Rasmussen, Peissig, McCarty, & Starren, 2012). There are already mature technologies that would allow nurses the freedom of movement paper systems offer, such as handhelds and tablets (Coopmans & Biddle, 2008; Di Pietro et al., 2008). It is notable that nurses have expressed some optimism, despite the clinical workflow changes, because clinicians

recognize that data input is, at least conceptually, a necessary and worthwhile imposition (Anderson & Willson, 2008; Kossman & Scheidenhelm, 2008).

CDSS data output. The CDSS in this study is intended to standardize patient care by reducing or eliminating subjective and variable interpretations and interventions (Penn Medicine, 2012; Penn Medicine, 2015). CDSSs are also designed to manage treatment in an efficient and cohesive way. Nurse knowledge workers are obliged, as such, to refer to the system at regular intervals, and to assure that their actions are synchronous with those of the clinical care team. Even the prosaic aspects of this periodic orientation, such as scrolling and mouse clicks to navigate the CDSSs rich graphical user interface, and to review the extent of guidelines and recommendations has been shown to have a negative impact on workflow and contribute to nurses' unfavorable perceptions of CDSSs (Collins et al., 2012; Embi et al., 2013; Sockolow et al., 2014).

CDSSs actively generate alerts and reminders, intended to keep clinicians on task with the needs of individual patients. Studies have shown, especially with the recent proliferation of CDSSs and EHRs, a rise in "alert fatigue" (Feldstein et al., 2004; Sidebottom, Collins, Winden, Knutson, & Britt, 2012). In the worst circumstances, this may result in missed nursing opportunities or promote mindless, unnecessary and potentially harmful compliance. Occurrences of this type have been termed *e-iatrogenesis* (Weiner, Kfuri, Chan, & Fowles, 2007). Research has shown that the totality of many seemingly negligible distractions, such as acknowledging an alert in the midst of providing routine care, may cost a knowledge worker 15% to 25% of their day (Spira, 2011). Further, the amount of time it takes a knowledge worker to reacquire thoughts, often exceeds, by 10 to 20 times, the duration of the initial distraction. Research has additionally demonstrated that the effectiveness of CDSSs decreases when clinicians are subjected to alerts and other information which are perceived to lack benefit (van der Sijs et al., 2009). Therefore, it is important for hospitals to preserve the relevance of alerts (Anderson & Willson, 2008;

Feldstein et al., 2004). This includes adjusting trigger sensitivity, eliminating unnecessary and duplicate alerts, and structuring alerts so that they reside within the nurses' actionable event horizon: not from the last shift or anticipating the next. Additionally, alerts should address issues specific to the nurses' discipline, and present specific resolution steps (Bates et al., 2003; Harrington et al., 2011; Russ, Zillich, McManus, Doebbeling, & Saleem, 2012; Saleem et al., 2009).

With respect to clinical workflow, it is important for nurse leaders to resist the impulse to integrate CDSSs into existing patterns of practice (Bakken et al., 2008; Kim et al., 2011; Sternberg & Preiss, 2005). Because it is difficult to anticipate the impact of a CDSS prior to implementation, it is important to subject workflow processes to continual cycles of review and refinement (McBride & Detmer, 2008). It is equally important to elicit clinicians' feedback and to exploit technological trends and developments to improve the delivery of clinical content. Research shows, for example, that integrated dashboards are just one way that systems are being optimized to intuitively convey the "patients' story" (Anders et al., 2012; Effken, Loeb, Kang, & Lin, 2008; Koch et al., 2013; Varpio et al., 2015a, p. 1021; Varpio et al., 2015b).

Depersonalization of Patient Care

Mixed method observational studies have demonstrated that entering and using data from CDSSs diminished nurse knowledge worker's ability to engage in face-to-face patient communication, and can generally reduce the time nurses have to appraise patients in a holistic way (Campion et al., 2011; Harrington et al., 2011; Sockolow, Rogers, Bowles, Hand, & George, 2014). Clinicians cite that the loss of eye contact (Linder et al., 2006) and the attention they must devote to EHRs and CDSSs as akin to a virtual presence: a "third party" which leaves patients competing for the clinicians' attention (Lown & Rodriguez, 2012; Verghese, 2008). Mixed methods studies have described patient interactions with their nurses and providers as being

punctuated, and marked by abrupt topic shifts and pauses in order to accommodate typing in the EHR (Doebbeling, Chou, & Tierney, 2006; Ludwick & Doucette, 2009; McGrath, Arar, & Pugh, 2007). Nurses, in one online survey, expressed that it seemed that they were "...nursing the chart rather than patient" (Stokowski, 2013). This perception may help to account for the significant declines in the *HIT Depersonalizes Care* subscale (*HITDPC*). These perceived distractions may also help explain decreases in the patient family dynamic, I-HIT Item 5, "*HIT Allows for patient/family participation in care*" also decreased significantly for both samples from the pre- to post- implementation periods.

Because entering structured data into CDSSs imposes time constraints and detracts from patient individualization, it is important to leverage data to accentuate the patient experience, with inpatient hospitalization summaries, medication reconciliation comparisons, and targeted takeaway literature for self-care after discharge (Grant, Opie, Friedman, Adams, & Hughes, 2015; Kazley, Diana, Ford, & Menachemi, 2012). It is encouraging that studies have reported patients perceive graphs and other summarized data to be helpful, and that both clinicians and particularly patients find them to facilitate patient-clinician dialogue (Alkureishi et al., 2016; Kazley et al., 2012; Lee, 2014).

Clinical Autonomy

The impact of the CDSS on nurses' perceptions of their clinical autonomy and discretion is a major focus of this study as they are essential to the practice of nurse knowledge work (Antrobus, 1997; Benner & Tanner, 1987; Benner, 1984; Schon, 1983) and pivotal to the professional maturation of the nurse knowledge worker (Benner et al., 1997). Clinical autonomy involves making independent decisions based on pattern recognition, salience, and experiential learning, and requires the freedom to act (Kramer & Schmalenberg, 2008a; Kramer et al., 2006; Thompson & Dowding, 2001).

While the paired post-implementation EOM II *Clinical Autonomy (AUTO)* subscale resulted in a statistically significant increase, this finding was associated with a very small effect size (d = .2), for the paired sample only. These findings may suggest that nurses, paired and independent sample combined, perceived almost no operationally meaningful improvement in the practice environments' ability to support autonomy. More telling, the average weighted paired sample *AUTO* subscale remained just below or at 3.0, the threshold used to demarcate nurses' agreement that the practice environment supported aspects of their knowledge work.

The EOM II item that most directly assessed nurses' autonomy remained essentially unchanged. Item 14: "*On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decision in those spheres where nursing overlaps with other discipline"* increased only 0.2 across both samples. The IHIT subscale question which most directly measured autonomy, I-HIT Item 7: "*The ability of nurses to access information electronically has improved the ability to independently make decisions*" decreased .49 for the paired sample, and 0.21 for the independent. The item underscores that nurses' ability to autonomously act and make decisions is a dimensional issue, tied not only to CPGs which are designed to reign in subjective clinical judgments, but also on the CDSS's technical ability to facilitate access to information in a timely and accessible way (CMS: Centers for Medicaid and Medicare, 2014; Lee, 2014).

Knowledge work theorists and researchers regard evidence based practice as a means to temper overreliance on subjective clinical judgment, and promote quality and clinical outcomes (Aitken, Marshall, Elliott, & McKinley, 2009; Antrobus, 1997; Benner et al., 1996; Lee, 2014; Snyder-Halpern et al., 2001). CDSSs are advanced by software vendors, hospital administrators, and nurse leaders as a way to deliver evidence to clinicians at the point-of-care. It is important, however, for nurse leaders to acknowledge that CDSSs are not inherently compatible with the deliberative style of practice, and the cultivated clinical intuition ascribed to nurse knowledge

workers. The CDSS in this study for example, was not expressly structured to allow the selective application of clinical guidelines (Dowding et al., 2009). Deviations from the guidelines require the nurse knowledge worker to supply a clinically defensible explanation (Roshanov, 2013). Studies have found that nurses may be reluctant to deviate from recommendations and guidelines, because they perceive that it would invite scrutiny and possibly punitive measures (Campion et al., 2011; Embi et al., 2013).

The preservation of clinical autonomy and decision-making has been identified as important determinants of CDSS failures and disuse. A study commissioned to examine the progress of EHR implementations, required by the HITECH Act, exposed that clinicians' loss of autonomy posed a significant barrier to adoption of CDSSs ("Report to Congress: Update on the Adoption of Health Information Technology", 2014). An investigation of 309 physicians drew attention to the fact that CDSSs can provoke fear over loss of clinical autonomy, commoditization of their expertise, and the dissemination of knowledge to peers, as well as concerns that CDSSs were harbingers of their displacement (Esmaeilzadeh, Sambasivan, Kumar, & Nezakati, 2015; Sambasivan, Esmaeilzadeh, Kumar, & Nezakati, 2012; Walter & Lopez, 2008). Further, CDSSs and EHRs are vulnerable to disuse if perceived to devalue the traditional hierarchies, and practitioner discretion that exist in healthcare settings (Cresswell, Morrison, Crowe, Robertson, & Sheikh, 2011; Friedberg et al., 2013; Lawler, Cacy, Viviani, Hamm, & Cobb, 1996).

Control over Nursing Practice

The *Control over Nursing Practice (CNP)* subscale, according to the authors' of the EOM II, measured nurses' perceptions about the success of nurse leaders to create shared governance structures that support clinical nurses in negotiating policies, evidence-based practice standards, and technology foundational to their practice (Kramer & Schmalenberg, 2003). This advocacy helps sanction the freedom nurses have to act on clinical deliberations, and spans

clinical units and health systems (Kramer et al., 2008; Weston, 2010). The *CNP* subscale score increased significantly for the paired and independent samples. Despite small improvements in subscale scores, both the paired and independent samples remained below the level of agreement, indicating that nurses were not satisfied with either the level of clinical autonomy they had, or the practice environments' commitment to independent practice. Two *CNP* subscale items help to illustrate nurses' perceptions about *CNP*. EOM II Item 27*, "Nursing practice, policies, issues and standards are determined by nursing management, administration, or people outside of nursing, staff nurses do not have control"* and EOM II Item 23, "*Shared decision-making is more talk than action here; clinical (staff) nurses don't take part in decision-making"* both increased only slightly. The healthcare literature clearly indicates a need for clinicians to actively participate in selecting, planning, building, and implementing clinical information systems to ensure that structures and processes integrate into workflow (Bakken et al., 2008; Byrne, Dylan, Mercincagave, Johnston, Pan, & Schiff, 2013; Horsky et al., 2012; Piscotty, Kalisch, & Gracey-Thomas, 2015; Weber, Crago, Sherwood, & Smith, 2009). However, the CDSS implementation in this study did include a robust, interdisciplinary, participative process, making these results challenging to interpret. It is possible that the structures and processes used during CDSS implementation did have a positive impact on the *CNP* mean subscale scores, and would have been lower had the participative process not been used.

Evidence-Based Clinical Practice Guidelines, CDSSs and Knowledge Work

CDSSs are promoted by administrators and vendors as a means to centralize clinical work processes and standardize patient care with best evidence (Blumenthal, 2011; Garg et al., 2005; Jha et al., 2010; Penn Medicine, 2012; Penn Medicine, 2014). The objective is to reduce errors, omissions, redundancies, and inefficiencies attributed to subjective clinical judgments (Coopmans & Biddle, 2008; Lee, 2014; Robert Wood Johnson (RWJ)/ Institute of Medicine

(IOM), 2010). Clinical practice guidelines, distilled from scientific medical and nursing studies, using data mining techniques and statistical analysis (Zheng, 2011) are an important part of this strategy. CPGs are of particular interest to this study, because they exemplify the stratification of knowledge work and the tendency of expertise to concentrate into smaller groups of highly credentialed individuals (Bates, 2016; Crawford, 2009; Garson, 1988; Segen, 2010). In this case healthcare leaders, discipline-specific specialists, and prominent academicians work to achieve consensus about evidence-based treatments and assessments (Penn Medicine, 2012). The resultant guidelines instruct clinicians to perform tasks in ways that rely less on their subjective clinical judgments, and experience which contribute to variations in care and error (Brokel, 2009; Majid et al., 2011).

The institution in this study leveraged the services of the *Clinical Practice Model Resource Center* (CPM Resource Center, 2011), a national consortium of hundreds of hospitals and educational institutions, to handle the formidable work of writing, maintaining, and compiling the evidence that informs the CPGs. The CPGs were additionally scrutinized by an interdisciplinary group of study site direct care clinicians to ensure customization to the level and sophistication of the institution's practice. The CDSS uses the guidelines by matching patient information and physician orders against its database of CPGs, and then populating graphical user interfaces with specific assessments and treatment recommendations (Penn Medicine, 2012; Sim et al., 2001).

The I-HIT study results indicated that nurses did not perceive that the CDSS and CPGs improved practice. I-HIT Item 12, "*The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care"* decreased .57 for the paired sample, and .47 for the independent sample. I-HIT Items 16 and 17, which assessed nurses' perceptions of the CDSS to support care and treatment planning, decreased for both the paired and independent samples (range -.30 to -.58). Efficiency, which is a

primary argument for CPGs, saw some of the largest I-HIT declines. I-HIT Item 4, "*HIT facilitates practice efficiency"* declined .96 for the paired sample, and .70 for the independent sample. I-HIT Item 9, "*Work lists generated from HIT tools support efficient patient care"* fell .71 for the paired sample and .47 for the independent sample. Confirming these findings, the clinical practice guidelines were also not perceived as having helped to coordinate patient treatment across disciplines. Item 15, "*The ways in which data and information are displayed reduces the redundancy of care"* decreased .60 for the paired sample, and .93 for the independent sample, marking one of the I-HIT's largest declines.

The EOM question that most directly assessed nurses' perceptions of the CDSS' ability to support knowledge workers with evidence, Item 15, "*Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions*" measured essentially no change. The mean score increased .06, for the paired sample, and .02 for the independent sample. The *Nurse-Assessed Quality of Patient Care on Unit* (*QoC*), a single-item subscale that measured the "*Usual quality of care delivered on the patient care unit*" did not prove statistically significant for either the paired or the independent sample. *Professional Practice Satisfaction (PPS)* was significant only for the paired sample which indicated a slight 2.3% increase. The *Working with Clinically Competent Peers* (*CCP*) subscale increased significantly for the independent sample only.

The I-HIT subscales indicate that nurses perceived that the CDSS and CPGs negatively influenced their ability to practice aspects of their knowledge work. The EOM II results, however, remained essentially static with slight improvements and no statistically significant declines. This is an unexpected and interesting finding. Nurses perceived that the CDSS and CPGs interfered with their clinical workflow and ability to prepare for daily caseloads; decreased their ability to personalize care*;* impeded access to and use of information; and reduced communication with members of the care team. In particular, they perceived that the CDSS and

CPGs did not mitigate the occurrence of clinical redundancies, and did not improve practice efficiency. Yet, these decreases were not reflected in the EOM II's assessment of the practice environment, especially in terms of *Professional Satisfaction, Nurse-Assessed Quality of Patient Car*e, *Patient-Centered Values*, *Autonomy*, and *Control over Nursing Practice.* These divergent results suggest that nurses recognized functional limitations with the CDSS. However, they did not repudiate the evidenced-based models of practice the CDSS and CPGs represented. Even though this modality may be perceived as "cookbook" care formulated to limit their clinical discretion, autonomy, and constrain variability (Hoff, 2011, p. 339; Jansson, Bahtsevani, Pilhammar-Andersson, & Forsberg, 2010; McCluskey, Vratsistas-Curto, & Schurr, 2013; Miller et al., 2015; Quiros, Lin, & Larson, 2007; Segen, 2010; Timmermans & Mauk, 2005; van de Steeg, Langelaan, Ijkema, Nugus, & Wagner, 2014; Weber, 2007).

Mixed method studies have demonstrated that nurses and physicians embrace the benefits of CDSSs and CPGs, even when they are perceived as disrupting clinical workflow, patient interactions, and autonomy (Anderson & Willson, 2008; Jun, Kovner, & Stimpfel, 2016; Kossman & Scheidenhelm, 2008; Randell & Dowding, 2010; Sockolow et al., 2014). A mix method study of 78 primary care physicians, for example, found the time it took to follow CPGs preempted patient conversations and "serendipitous" discoveries, and inhibited the use and cultivation of clinical skills (Hoff, 2011, p. 346). Nevertheless, all 78 of the primary care physicians supported the practice guidelines; and particularly welcomed them as an objective standard of accountability (Hoff, 2011). Further, it has been demonstrated that nurses do not object to CPGs on principle, but prefer more streamlined and intuitive versions (Jansson et al., 2010; Lockwood & Hopp, 2016; Quiros et al., 2007).

It may be that the nurses in this study, uniquely positioned to comprehend the complexities that are pushing the practice environment to its limit, recognize the compelling case for standardized, centralized, and process-oriented nursing care, premised on a foundation of best

evidence (Dunn Lopez et al., 2016; Institute of Medicine, 2003; Melnyk, Fineout-Overholt, Gallagher-Ford, & Kaplan, 2012). Preventable harm is accountable for 400,000 deaths per year, in the U.S. alone, and at a cost of nearly one trillion dollars (Park et al., 2009). Serious harm seems to be 10- to 20-fold more common than lethal harm (James, 2013). Nurses and clinicians have limited time and finite information processing capacity that may precipitate mistakes and missed care (Carr, 2014; Institute of Medicine, 2001; Melnyk et al., 2012; Weed, 1968). Furthermore, it is exceptionally difficult for clinicians to remain abreast of studies and literature. Medical information was estimated, in 2010 to double every three years, by 2020 it will double every 73 days (Densen, 2011).

Situational awareness and flexibility enable nurse knowledge workers to resolve novel problems and care for patients in individualized ways (Antrobus, 1997; Brooks & Scott, 2006; Jost, 2012; Sorrells-Jones & Weaver, 1999a; Weaver & Sorrells-Jones, 1999). Yet, the number of preventable harm instances alone, 400,000 per year, is sufficient to compel guidelines, process management, and evidence based healthcare. EHRs, CDSSs, and CPGs, have in only a few short years, become the mechanism to promote processes, gather information, induce compliance, and reduce subjective clinical judgments (Holroyd-Leduc, Lorenzetti, Straus, Sykes, & Quan, 2011; Lee, 2014). This approach is virtuous in many respects, and has demonstrated improved quality process and patient outcomes (Appari, Johnson, & Anthony, 2013; Bright et al., 2012; Walter & Lopez, 2008). The challenge for nursing science is to strike the balance between process and practice by investigating and influencing system design in ways that optimally apportion standardization, autonomy, and decision support (Head, 2013).

Specific Aim 2

Nurse and Patient Care Unit Attributes that Explain Differences in Nurse Perceptions

To address specific aim 2, GLM regression models were used to examine I-HIT and EOM II nurse and clinical unit independent variables. The analysis found that the majority of variance was explained by clinical unit type, shift, clinical ladder, race, prior experience with clinical documentation systems, and whether or not the RN's education was obtained outside of the USA. Independent variables such as age, years of experience, institutional tenure, and educational level explained less variance.

Clinical Unit Type and Clinical Unit Type*Time. The regression model analysis identified the main-effect *Clinical Unit Type* ($f = 24$) and the interaction term *Clinical Unit Type*Time* ($f = 16$) as appearing with the greatest frequency and the largest effect sizes. *Clinical Unit Type* appeared in a high percentage of final models for both the I-HIT (80%) and EOM II (90%), which suggests that the type of unit where nurses practiced strongly influenced their perceptions. The interaction term *Clinical Unit*Time* decreased for all of the post-implementation I-HIT subscales. The analysis of the I-HIT results found that nurses from Medical units perceived CDSSs most favorably, and Women's Health and Intensive Care Unit (ICU) nurses had the least positive views. The analysis of the EOM II subscales found less change over time, and identified the ICU and Intermediate clinical units nurses as most satisfied.

Research concerning the influence of clinical unit type on nurses' perceptions of EHR and CDSSs is limited. In an older study of nurses' attitudes about the impact of computerization in a Midwestern community hospital, (Brodt & Stronge, 1986) identified that Women's Health and ICU nurses viewed computerization most favorably, while Mixed Medical-Surgical nurses held the least positive views. These results were not supported in the current study. A replication of the Brodt and Stronge (1986) study similarly found that Geriatric, Rehabilitation, and Medical units

held the least favorable attitudes toward computerization (Simpson & Kenrick, 1997). A study of 411 RNs in a 1,100 bed Israeli hospital suggested that nurses' perceptions about computer applications depended less on their unit type, and more on their satisfaction with the work environment (Shoham & Gonen, 2008). The authors concluded that when clinical nurses perceive support from their peers and leaders, they are more likely to believe they can successfully work with an EHR. More recent studies have also confirmed the role of a supportive work environment in facilitating EHR and CDSS integration into practice (Gagnon et al., 2010; Randell & Dowding, 2010).

The results in the current study found that some clinical unit types, such as ICUs and Women's Health, simultaneously had some of the lowest I-HIT estimated marginal mean (EMM) subscale scores, and some of the highest EOM II scores. These discrepant results may relate to regular use of specific unit technologies such as, adult hemodynamic and fetal heart monitors, ventilators, and infusion pumps, which were unable to supply documentation directly to the CDSS. This underscores that CDSSs are designed in a structured, rigid, and in a somewhat generic way (Campion et al., 2011; Miller et al., 2015; Varpio et al., 2015b), and address the needs of some units more than others. Determining units that may have incompatible technologies that align poorly with CDSSs represents an opportunity for future research.

Shift and Shift*Time. The main effect independent variable *Shift* (*f* = 19*)* and the interaction variable *Shift*Time* (*f*=7) were the second most frequently occurring independent variables, appearing in final regression models 63% of the time. Nurses who worked day shift were more satisfied, post CDSS implementation, than those who worked nights. Nurses who reported working rotating shifts on average perceived no more satisfaction with practice or environment than those who worked day or night shifts.

In contrast to the findings from this study, Kaya (2011) found that *Shift* did not predict (*p* = 0.6) nurses' (*N* = 1,085) attitudes about hospital computer systems. However, night and rotating

shifts have been found to disrupt nurses' circadian rhythms and sleep (Flo et al., 2012), as well as cause emotional stress, burnout, and compromise health (Jamal, 2004). Sleep and circadian rhythm disturbances have also been shown to negatively impact psychological processes such as mood (Golder & Macy, 2011), and have been shown to influence employee attitudes (Judge & Kammeyer-Mueller, 2012). A recent study of nurses who worked nights and weekend shifts were more likely to report negative perceptions of workplace climate, supervisors, and overall fairness (Teclaw & Osatuke, 2015). The current study found that *Shift,* perhaps attributable to these factors, influenced nurses' perceptions of the CDSS and practice environment. This is a particularly important finding because the majority of nurses work in inpatient settings that require 24-hour staffing coverage, requiring approximately 30% of all healthcare employees to work non-standard hours (McMenamin, 2007). Additional research is needed to understand the unique needs of off shift workers in relationship to healthcare technology.

Age, Total Years of Experience, and Institutional Tenure. A widespread perception in the healthcare management literature is that younger clinicians are more accepting of and facile with technology than older employees. These perceived generational differences are said to explain different rates of technology acceptance among so-called "Baby Boomers," "Generation Xers" and "Millennials" (Sarringhaus, 2011). The current study, however, found the independent variables *Age*, *Institutional Tenure,* and *Total Years of Experience* were significant for only two of the EOM II survey subscales, and for none of the I-HIT. Other nursing studies offer mixed results. The majority of studies identify *Age* as a non-significant predictor of technology acceptance (Brodt & Stronge, 1986; Burkes, 1991; Ifinedo, 2016; Marasovic, Kenney, Elliott, & Sindhusake, 1997; Raja, Mahal, & Masih, 2004; Sleutel & Guinn, 1999; Villalba-Mora, Casas, Lupianez-Villanueva, & Maghiros, 2015). Three studies found that younger nurses were likely to be more satisfied with technology (Brumini, Kovic, Zombori, Lulic, & Petrovecki, 2005; Kaya, 2011; Simpson & Kenrick, 1997). Only one study found that older nurses were more receptive

and satisfied with technology (Dillon, Blankenship, & Crews, 2005). Similarly, *Total Years of Experience* was found to have mixed results in the literature. Half of the studies found no statistically significant predictive relationship (Burkes, 1991; Ifinedo, 2016; Kaya, 2011; Marasovic et al., 1997; Raja et al., 2004). The remaining results were split. Some indicated a significant predictive relationship between *Total Years of Experience* and positive perceptions (Brodt & Stronge, 1986; Shoham & Gonen, 2008), and others indicated that less experience predicted positive perceptions (Burkes, 1991; Simpson & Kenrick, 1997). *Institutional Tenure* appeared only twice in the literature with mixed results (Brodt & Stronge, 1986; Simpson & Kenrick, 1997).

Clinical Ladder and Clinical Ladder*Time. In this study C*linical Ladder* (*f*=15) and Clinical Ladder*Time (*f*=9) were among the most frequently included variables in the final regression models. While the independent variables *Age*, T*otal Years of Experience*, and *Institutional Tenure* accrue with passage of time, the four levels of the *Clinical Ladder* are ascended on the basis of clinical exemplars, essays, and peer-review. *Clinical Ladder* consequently differentiates nurses based on their motivation to attain expertise. This study showed that Level 1 nurses (Novice)—were more satisfied across all subscales than those inhabiting Level 2 (Competent) and Levels 3 & 4 (Expert). These findings might be explained by novice and expert nurses' preferences. Research has demonstrated that novice nurses desire as much information as possible to support their decisions, and desire wholesale recommendations and instructions, in ways experts do not (O'Neill, Dluhy, Fortier, & Michel, 2004). Experts, alternatively, are more selective. They combine recommendations, information, and experience in more fluid and independent ways (Cho, Staggers, & Park, 2010; Hoffman, Aitken, & Duffield, 2009). The results from this study suggest nurse perceptions similar to this prior research. Novice nurses, more than their expert counterparts, appreciated the structured assessment and

documentation templates, standardized interventions, care plans, and reminders and may have regarded the distilled knowledge and experience contained in CPGs as superior to their own.

Race and Ethnicity. *Race* appeared in final regression models a total of 18 times (main-effect f=10, interaction f = 8). Nurses identifying as *White* generally had an unfavorable perception of the CDSS's impact on their practice and work environment. *Race* appeared in 90% of the I-HIT final models and in only 5% of the EOM II. This suggests that race disproportionately affected the way nurses' perceived the technical ability of the CDSS to support aspects of their practice. The literature offers no studies and no guidance about *Race* as a predictor of nurse perceptions of technology. The study sample, while more diverse than national benchmarks (U.S. Department of Health and Human Services, 2010), was predominantly *White* (range from 70.6% for the independent sample to 78.4% for the paired sample), and makes generalizability of the findings challenging. More research is needed to fully understand whether a meaningful relationship between race and nurse perceptions of technology exists, or whether race as a predictive variable is confounded by other nurse attributes, such as age, and expertise. Given that most studies of nurse perceptions of EHRs or CDSSs have relatively small to moderately sized samples, a meta-analysis of results may provide insight into this relationship.

Education Obtained Outside of the USA. *Nurses Educated Outside the USA*, predominantly from the Philippines and African nations, generally perceived the CDSS favorably impacted their practice. This confirmed studies that found internationally educated RNs, working outside of the U.S., held favorable views of electronic health records and CDSSs (Alquraini, Alhashem, Shah, & Chowdhury, 2007). Studies of internationally educated nurses working in the U.S. also reported generally favorable views of information technology, provided they were afforded adequate training. Internationally educated nurses reported technology in U.S. hospitals to be similar or superior to those in their country of origin (Edwards & Davis, 2006; Wheeler, Foster, & Hepburn, 2013).

Prior Experience with Electronic Clinical Documentation Systems. Consistent with expectation and previous research, this study found that nurses who reported *Prior Experience with Nursing Electronic Clinical Documentation Systems* viewed the CDSS more favorably than those who did not (Brumini et al., 2005; Ifinedo, 2016; Whittaker, Aufdenkamp, & Tinley, 2009b). However, other studies found no predictive relationship with prior system experience (Dillon et al., 2005; Sleutel & Guinn, 1999).

Highest Educational Degree Attained. Diploma and associate degree prepared nurses perceived the CDSS more favorably than those with a bachelor's degree; master's and doctorally prepared nurses had the least favorable perceptions of the CDSS. This inverse relationship between the level of education attained and CDSS acceptance may result from the way nurses use information. Research has found that advanced practice nurses (APNs) regard CDSSs as a "safety net", and tend to employ it as a means to validate their own clinical judgments (O'Cathain et al., 2004; Weber, 2007). The master's and doctorally prepared nurses in this study may have similarly placed confidence in their own ability to render clinical judgments, and may have been less likely to rely on the CDSS. The favorable perceptions of diploma and associate prepared nurses may have reflected their willingness to accept and follow the CDSS guidance. Prior research found that, in the majority, increased educational level predicted the increased acceptance of electronic health records (Brumini et al., 2005; Ifinedo, 2016; Kaya, 2011; Shoham & Gonen, 2008). However, those studies addressed a mix of technologies that, in the aggregate, less explicitly proffered guidance and clinical recommendations. More educated nurses may find essential information, such as clinical history helpful, but may be less interested in receiving explicit guidance. Additional research is required to clarify this issue.

Discussion of the Conceptual Model

The Quality Health Outcomes Model (QHOM) (Mitchell et al., 1998), presented in *Chapter 2*, Figure 2.1, provided the framework to examine the impact of the CDSS on nurses' perceptions of their knowledge work and the work environment. The QHOM seeks to explain relationships between the system, client, interventions, and outcomes by evaluating the characteristics of model concepts: *System, Intervention, Client, and Outcome*. The QHOM was chosen because it represents an expansion of Donabedian's linear *structure, process, and outcome* model by recognizing the dynamic, multidirectional nature of nursing practice set within the healthcare environment (Mitchell et al., 1998).

The results of this study suggest that the CDSS implementation impacted the complex relationships between the work environment and nurses' perceptions of their ability to perform aspects of knowledge work, and was associated with disruptions in intraprofessional communication patterns; workflow processes; and nurses' perceptions of the impact of the technology on patient care. The results also suggest that the processes that impacted nurse perceptions were multifactorial, bidirectional, and non-linear —suggesting that the QHOM was appropriate to guide this research.

The literature suggests that healthcare environments are so complex (Ackoff, 1999; Ash, Sittig, Campbell, Guappone, & Dykstra, 2007; Cornell et al., 2010), and associated with high levels of clinician cognitive workload (Potter et al., 2005), that the use of RCTs when examining the impact of CDSSs is inadequate (Ammenwerth et al., 2006; Kaplan, 2001a). The CDSS literature is replete with recommendations for future studies to include social, professional, and organizational context factors (Ash et al., 2004; Coiera, 2000; Kaplan, 2001b; Miller et al., 2015). Organizational complexity scientists urge the application of *systems thinking* as a more inclusive method of evaluating the impact of CDSS on the work environment (Plsek & Wilson, 2001; Rothschild et al., 2005; Snowden & Boone, 2007). With its broad evaluative lens, the QHOM

could nicely accommodate more pluralistic methods of CDSS evaluation and frame more robust examinations of CDSS features that would better accommodate the dynamic workflow processes of nurses. Future studies using the QHOM could also accommodate examination of the CDSS's impact on patient outcomes.

Study Limitations

This study evaluated a CDSS implementation, using a quasi-experimental pre- post- research design, which is known to have inherent limitations, and inhibits the identification of casual inferences (Polit & Beck, 2010). Studying the implementation of information technology systems in healthcare settings is challenging, because researchers are often unable to randomize subjects into groups. For example, it would be difficult to situate a study in a fully operational setting, that would simultaneously investigate one group of nurses using a CDSS and another group using a paper-based system. In addition, HIT implementations are often done throughout the entire organization, all at once, which negates the ability to have a usual care or control condition. Information technology is also challenging to assess, because it is difficult to find duplicate study opportunities, such as a nearby hospital implementing the same CDSS system at the same time. These practical limitations prompted the use of a pre- and post-, historical control design that is a widely accepted method of examining healthcare information systems (Friedman & Wyatt, 2006). The pre- post- design also introduced recall bias, as nurses in the paired sample completed the survey twice, and were acquainted with the survey questions. However, nurses in the independent sample were not subject to recall bias and served to validate the paired sample.

The post-implementation survey was administered 8 months after the CDSS system go-live. The health information science research literature has specified that six months post-implementation is the minimum time required for the environment to stabilize (El-Kareh et al., 2009; Friedman & Wyatt, 2006). However, considering the complexity of the CDSS

functionality, associated changes to the clinical workflow, and the size and nature of the study site, perhaps a longer interval before the initial post-implementation survey, or the addition of a third measurement point may have allowed for more system acclimatization to occur.

The study design was not able to control for any organizational changes that took place between the pre- and post- survey administrations. For example, new quality improvement initiatives, other equipment implementations, mergers with other healthcare systems, or leadership changes. In spite of this limitation, no serious organizational changes were known to have occurred. The organization was in a stable period between Magnet surveys: nurse staffing levels were at or near budgeted levels and stable; turnover was modest; and hospital/health system leadership remained consistent during the study data collection periods.

This study used a convenience sample of RNs working in one urban, academic medical center. The sample was younger, less experienced, and more educated than the national average (U.S. Department of Health and Human Services, 2010), which may limit the generalizability of the findings. The sample likely mirrored other large academic medical centers, but may not have reflected nurses working in rural or non-academic institutions. Also, while the site provided access to nurses working with a full range of adults with medical, surgical, critical care, and obstetrical needs, the applicability of the CDSS to the care of children, patients with mental health problems and during the peri-operative-phase was not tested. A strength of this study was that the sample was more representative of racial, ethnic and gender minority groups than national benchmarks (U.S. Department of Health and Human Services, 2010), but nurses were still primarily Caucasian and female. The sample diversity may not have been sufficient to allow inferences about the degree to which race and gender predict nurses' perceptions of CDSSs. Additional studies, situated in more diverse settings and, perhaps using combined data sets, are necessary to build on this area of the science.

Nurses who participated in this study were assured that their responses would remain confidential, and that results would be reported only in an anonymous fashion. Despite these assurances, the study was situated at the respondents' workplace, inquired about nurses' colleagues, and related to a CDSS chosen and promoted by senior administrators. These factors may have, despite assurances of absolute confidentiality, raised concerns about unfavorable assessments, and influenced the studies' findings. The REDCap survey administration was chosen for its discreetness and to help alleviate such apprehensions. REDCap allowed survey responses to be completed and submitted from any location and on nearly any device, and allowed subjects to pause and restart surveys in as many sessions as required.

The study participants interacted with only one CDSS, and with only one set of features and design elements. This is a major limitation, as there are many possible points of differences between CDSS systems, including the graphical user interface, the accuracy of the CPGs, and the reliability of the system. This study design did not include any in situ qualitative techniques to observe and record nurses' real time interactions with the CDSS. This may have provided valuable insight into which CDSS's features nurses favored, and which they found to inhibit their practice.

The instruments used in this study, the *Impact of Health Information Technology* (*I-HIT*) and *Essentials of Magnetism II* (*EOM II*) were selected because they were reliable and valid, and because they measured a number of attributes associated with nurse knowledge work. These included aspects of: autonomous decision-making, interdisciplinary collaboration, care coordination, problem solving, data synthesis, and communication. Nevertheless, these instruments were not solely intended for measuring knowledge work, and almost certainly neglected some concepts while including extraneous questions.

The *EOM II* consists of a 4-point Likert scale, ranging from "*Strongly Agree"* to "*Strongly Disagree*." This relatively limited response range, compared with the six-points used by

the *I-HIT*, or a ten-point scale, may have failed to capture some outcome variance. The *EOM II*, however, has been used in many studies and has consistently demonstrated reliability and validity. The *I-HIT* too has a record of demonstrated reliability and validity. It was recently used to measure nurses' perceptions about the mediating effect CDSS alert features (Piscotty et al., 2015), and its validity has been demonstrated in both U.S. (Dykes et al., 2007) and international (Cook & Foster, 2009; Dykes et al., 2009) samples.

Finally, despite the limitations, this study provided new insight into the relationship between a CDSS implementation, nurses' perceptions of their ability to perform aspects of knowledge work, and their practice environment. A more complete understanding of these relationships will be complemented by studies which also evaluate patient outcomes. The findings presented here may serve facilitate that important objective and serve as a foundation for building a body of knowledge in an area of growing importance.

Recommendations for Future Research

Since the passage of the HITECH Act in 2009, CMS has paid out over $35 billion in incentives (CMS: Centers for Medicaid and Medicare, 2016; Joseph, Sow, Furukawa, Posnack, & Chaffee, 2014) spurring unprecedented rates of EHRs and CDSSs adoption in hospitals (Dranove, Garthwaite, Li, & Ody, 2015). This has provoked abrupt change and challenged clinicians to assimilate new technology into established modes of practice. This study and others, as well as prevailing sentiment in the literature, suggest nursing researchers should now partner with CDSS and EHR systems engineers to identify, design and test systems that are calibrated to the needs of practice. This prominently includes their workflow, inter-professional collaborations, and use of information to render patient-specific decisions. CDSS systems of the future must be designed so that they are not simply layered on top of existing EHRs, a tactic that potentially interrupts

existing patterns of nurse workflow. Instead, intelligent integration to enhance the professionalism of practice is needed.

When considering the varied, socio-technical and political organizational factors involved in studying CDSSs implemented in healthcare systems, the Quality Health Outcomes Model (QHOM) (Mitchell et al., 1998), described in *Chapter 2*, continues to provide a useful framework to guide future nursing research.

System Factors

Studying the impact of a CDSS in the acute care setting will benefit from mixed method designs, including in situ observations to identify system features nurses find most helpful--particularly those that emulate the way knowledge workers communicate, collaborate, and make decisions. Studies should directly compare nurses' perceptions of their ability to perform knowledge work when using EHRs embedded with decision support versus when using EHRs without it. These efforts should endeavor to measure nurses' ability to: (a) remember important patient clinical information, (b) recognize patterns and trends in data, (c) problem-solve and arrive at treatment interventions, and (d) synthesize data so as to grasp and communicate the overall clinical picture. This may help hospitals to make immediate and relatively inexpensive process improvements. Examining longitudinal CDSS utilization data would also provide useful information about the level of nurse/CDSS engagement; for example, conducting studies that quantify the rate and quality of CPG individualization may indicate whether nurses become inured to structured assessment and intervention templates, or whether they remain engaged with the system content. Such research would comprise a scientific basis to open a dialogue between nursing leaders and system vendors to design system modifications.

The implementation of CDSSs may easily require more time to assimilate than the eight-month observation interval used here. Future studies, therefore, should extend the study period

and increase the number and type of measurements. Additional observations may expose salient trends regarding the impact of CPGs and documentation templates on nurse knowledge workers' clinical decision-making and autonomy.

Future studies should also attempt to understand significant between-subject-factor differences in nurse's perceptions about their knowledge work, such as, clinical unit type, shift, expertise, race, and education obtained outside the U.S. This understanding would provide insight into how CDSSs may be better optimized to accommodate nursing knowledge work. Future research should also include rural and non-academic institutions where, (a) minority racial, ethnic, and gender groups may be represented differently than in this study; (b) the practice environment may have different programs and resources designed to promote advancement and quality initiatives; and (c) nurses may be older, more tenured, and have less years of education.

Intervention

This study was limited because it evaluated the impact of one CDSS, which was the product and version of one vendor. While the CDSS evaluated in this study is integrated into the EHR, and is the type predicted to dominate the market place until 2022 ("Global CDSS Market Growth CAGR by 2022", 2016; P&S Market Research, 2016), future studies should evaluate other CDSSs in order to replicate findings and define characteristics of more effective systems. It is even more important for future studies to identify the CDSS they study. This should be done with the most precision possible, including the version of the CDSS and the build characteristics of the underlying software. This would allow researchers to better validate results, compare findings across studies, and would allow healthcare administrators to pursue CDSSs on the basis of very specific system attributes. Nursing leaders, in collaboration with industry vendors should be able to advance this research objective in the near term.

Outcomes

CDSS implementations comprise costly and time-consuming initiatives that may strain an organization's resources (Chaudhry, 2008; Kumar, & Aldrich, 2010). These are often undertaken because healthcare administrators presuppose implementation will improve clinical decision making by way of reduced practice variation and errors, and improve patient outcomes (Appari et al., 2013; Harrington et al., 2011). It is important that these assumptions are challenged with rigorous research. It is notable that the vast majority of CDSS research has been conducted in the ambulatory setting and has focused on physician practice while acute care hospitals, nursing, and nursing-sensitive outcomes have been significantly underrepresented (Miller et al., 2015). Recent studies examining the relationship between EHR/CDSS implementation and nurse staffing levels have demonstrated mixed results ; one study found a higher overall cost per patient day and higher nursing hours, while another found the opposite (Furukawa, Raghu, & Shao, 2010; Furukawa, Raghu, & Shao, 2011). These findings have potential implications for the availability of future nursing resources and have implications for care delivery models.

A logical long-term research objective is the development of a valid and reliable instrument, perhaps using grounded theory, specifically designed to measure nurse knowledge-workers' acceptance and use of decision support systems and their impact on care outcomes. It is notable that after the data collection phase of this study was complete, the first knowledge-work performance analysis instrument, *SmartWow---Smart Ways of Working,* was introduced (Palvalin, Vuolle, Jääskeläinen, Laihonen, & Lönnqvist, 2015). While not nurse knowledge work specific, the *SmartWow* instrument may allow, in the near term, a more precise way to assess the implementation of new systems and the impact on nursing knowledge work. It is confirmatory that the *SmartWow* shares many similarities with the I-HIT and EOM II used in this study, but is more focused and compact, consisting of four areas; work environment, personal work practices, well-being at work, and productivity.

Finally, clinical decision support, practice guidelines, and process-oriented electronic health record systems, naturally raise concerns about the preservation of clinical autonomy, changes to the patient/clinician dynamic, and the potential devaluation of nursing expertise (Jun et al., 2016; McCluskey et al., 2013; Quiros et al., 2007). These issues are fundamental to nursing professionalism and comprise the distinguishing characteristics of nurse knowledge workers. Yet, nursing has undertaken little research to clarify these concepts and drive system redesign (Anderson & Willson, 2008; Kossman & Scheidenhelm, 2008; Lee, 2014). Current initiatives, such as CDSS and clinical practice guideline implementations aimed at reducing ineffective and inaccurate variation in care, may deconstruct and reengineer nursing work into discrete steps, so that it may be performed in less autonomous ways. Nursing research needs to evaluate whether or not these approaches are viable, and if patient outcomes differ appreciably when less experienced and/or less educated nurses rely less on their individual clinical autonomy, and more on evidence-based practice guidelines, alerts, reminders, and system recommendations. This dilemma is often presented in the literature as an "all or nothing" scenario (Hoff, 2011; Timmermans & Mauk, 2005). However, the most effective model is, perhaps, a hybrid--somewhere along the continuum between complete CDSSs system-directed care and complete clinician autonomy. Research should provide a scientific basis to determine how far, and with what optimal mix of nurse training, expertise, and autonomy would best position nursing to interact with CDSSs and other forms of decision-making technologies to optimize nurses' satisfaction with their ability to perform knowledge work and ensure high quality patient outcomes.

Conclusion

This study is one of the first to investigate the impact of a CDSS on nurses' perceptions of their ability to perform aspects of knowledge work and on the practice environment. The study was conducted at a Magnet© designated academic hospital with 95% or better bachelor's prepared

nurses, and with an established EHR. The study used a pre-post design and a paired and independent sample designed to validate each other.

The results suggest that nurses were concerned about the functionality of the CDSS on aspects of their practice. They did not perceive improvements in their ability to communicate and share information among immediate and interdisciplinary team members, and perceived that the CDSS interfered with their workflows in ways that depersonalized care. Interestingly, nurses' perceptions about the practice environment remained essentially unchanged, with slight improvements and no statistically significant declines. This included nurses' perceptions about the clinical competence of their peers, autonomy, control over practice, patient-centered values, professional satisfaction, and the quality of patient care. This seems to suggest that concerns about functionality and workflow aside, nurses did not reject the potential of the CDSS and its practice guidelines to promote safe and consistent care, even though the CDSS is poised, at least in part, to deemphasize clinical autonomy and deliberative practice. This study also found that nurse and clinical unit characteristics such as clinical unit type, shift, expertise, race, and whether or not nurse education was obtained outside of the USA, explained more variance than years of experience, institutional tenure, and level of education.

This study underscores nursing science's need to investigate and advise the design of CDSSs, and to establish protocols to improve their implementation and use. This will involve tactics to optimize the CDSS's evidenced-based guidelines, and to leverage the CDSS's ability to govern and advise clinical processes. Nursing science is simultaneously challenged to defend and retain the character and wholeness of the nursing profession. This will prominently involve securing the attributes of autonomy, intuition, clinical discretion, and holistic care, foundational to the practice of nurse knowledge work.

APPENDIX A: PRE-STUDY E-MAIL COMMUNICATION

Nursing Knowledge Work /Knowledge-Based Charting
University of Pennsylvania
School of Nursing

Pre-Study e-Mail Communication to Potential RN Participants

Dear HUP Registered Nurse,

My name is Sandra Jost. I am a PhD nursing student at the University of Pennsylvania. I am writing to invite you to participate in my dissertation research. If you complete the survey, you will be entered into weekly gift card, e-Reader and "Grand Prize" (iPad2) raffles.

I am studying the impact of the Knowledge Based Charting (KBC) system, on nursing practice and the work environment.

To participate in the study, you will log into a secure University of Pennsylvania website, and complete survey questions. It will take about 20-25 minutes. The survey can be taken from ***any*** computer with internet access. You will be able to stop and restart the survey if needed. To do this, click "Save & Return Later" at the end of the survey. You will be given a code. Save this number to log in again. When completely finished, please be sure to click **"Submit."** If you misplace the code, contact me at sgjost@upenn.edu or at (609) 314-xxxx. I will provide you with the code.

Each week, there will be drawings for $25 gift cards for 15 participants! E-readers will also be raffled weekly. There will be one "Grand Prize" (iPad2!) raffle at the end of the enrollment. Complete the survey early for the best chance to win prizes!

APPENDIX B: REDCap GREETING

REDCap Greeting Page Text

Dear HUP RN,

Thank you for agreeing to participate in the Nursing Knowledge Work / Knowledge Based-Charting (KBC) study. Completion of the survey indicates you recognize that this is a research project in which you have volunteered to participate.

Your responses to this survey will be kept confidential. Data will only be shared in an aggregated, de-identified format.

If you need to pause while taking the survey, please click "Save & Return Later." You will be provided a code. Please write this code down and save it in order to resume the survey where you paused. If you do not have this code, you will be given the option to begin the survey again from the beginning. Or, you may contact me at sgjost@upenn.edu or (609)314-xxxx and I will provide you with the code. Please select and click "submit" at the end of the survey.

To be eligible for weekly gift card and "Grand Prize" iPad2 and e-reader raffles, all survey questions must be complete.

Thank you for your participation in this important research.

Sincerely,

Sandy

Sandra Jost, RN, MSN
PhD Pre-Doctoral Student
University of Pennsylvania School of Nursing

APPENDIX C: INFORMED CONSENT

REDCap Included Informed Consent

Title of the Research Study: Nursing Knowledge Work and Knowledge–Based Charting

University of Pennsylvania IRB Protocol Number: 813760

Co-Investigator: Sandra G. Jost, RN, MSN. Sgjost@upenn.edu. (609) 314-xxxx
Principal Investigator: Kathryn H. Bowles, RN, PhD, FAAN. Bowles@upenn.edu
418 Curie Boulevard Philadelphia, PA 19104-6096.

You are being asked to take part in a research study. Your participation is completely voluntary. If you decide to participate or not to participate there will be no loss of benefits to which you are otherwise entitled. Completion of the survey indicates you recognize that this is a research project in which you have volunteered to participate.

Q: What is the purpose of the study?
A: The purpose of the study is to learn more about the concept of nurse knowledge work. Specifically, the relationship between Knowledge Based Charting (KBC) and your ability to practice nursing is being examined. The impact of KBC on the work environment is also being studied.

Q: Why was I asked to participate in the study?
A: You are being asked to join this study because you are a clinical nurse working on a unit where Knowledge Based Charting will be implemented.

Q: How long will I be in the study? How many other people will be in the study?
A: The study will take place over a period of 10 months. I hope to enroll at least 609 nurses in the study. The more the better!

Q: Where will the study take place?
A: The study is about your practice and your unit work environment. The study itself is administered electronically. You can access the survey from ***any*** computer.

Q: What will I be asked to do?
A: You will be asked to complete a Web based survey about the impact of Knowledge Based Charting on your practice and the work environment. It should take you about 20-25 minutes. You may stop and restart (without losing data), if needed. If you participate, the same survey will be sent to you 6 months and 9 months after the KBC charting system is implemented. Very limited demographic data will be collected such as your age, gender, race, experience and clinical level so that differences that might have some impact on nurses' perceptions of the system can be analyzed.

Q: What are the risks?
A: There are no significant risks involved. A very limited amount of demographic data will be maintained during the study, such as race, gender and your name, e-mail and employee number. This data will be kept secure and confidential. The demographic data poses very low risk because it will be de-identified.

Q: How will I benefit from the study?
A: The survey data might help clinicians, nursing and hospital leadership to better understand KBC, your practice and work environment. Your participation will help me understand the value of nurse knowledge work.

Q: What other choices do I have?

A: Your alternative to being in the study is to not be in the study.

Q: What happens if I do not choose to join the research study?
A: Your participation is voluntary. There is no penalty if you choose not to join the research study. You will lose no benefits or advantages that are now coming to you, or would come to you in the future. Your nurse manager, CNO, or other hospital leaders will not be aware of your decision not to participate. While I hope you choose to participate, your decision not participate will be kept confidential.

Q: When is the study over? Can I leave the study before it ends?
A: The data collection will occur over 10-12 months. The analysis of the data will occur after the data collection is fully completed. You have the right to drop out of the research study at anytime during your participation. There is no penalty or loss of benefits to which you are otherwise entitled if you decide to do so. Withdrawal will not interfere with your future status or employment. If you no longer wish to be in the research study, please contact Ms. Sandra Jost at (609) 314-xxxx or at sgjost@nursing.upenn.edu

Q: How will confidentiality be maintained and my privacy be protected?
A: The PI will make every effort to keep all the information you tell us during the study strictly confidential, as required by the Institutional Review Board. The Institutional Review Board (IRB) at the University of Pennsylvania is responsible for protecting the rights and welfare of research volunteers like you. Any documents where you can be identified by name will be kept on a secure research site at the University of Pennsylvania.

Q: What personal information is collected and used in this study?
A: Characteristics about you such as your age, gender, and race will be collected for the purposes of statistically analyzing the survey data. Your employee number, name and HUP e-mail will only be used for purposes of contacting you for this study and will not be shared. Your name and employee number will be kept separately from your survey answers. Only Dr. Bowles and Ms. Jost will be able to identify you. All data will be de-identified and reported in aggregate. No individual level data will be reported.

Q: Who, outside of the hospital might receive your information?
A: The information collected for this study will be received by the study investigator. Your identifying information will be removed and kept in a secure electronic file. You will never be identified by name. All data will be reported in groups.

Q: How long may the University of Pennsylvania School of Nursing be able to use or disclose your information?
A: Your individual personal information will not be disclosed. Use of your survey response information for this specific study does not expire. Survey answer information may be held in a research repository database. Information such as your name and e-mail will be destroyed immediately upon study is completion.

Q: Who can I contact with questions, complaints or if I'm concerned about my rights as a research subject?
A: If you have questions, concerns or complaints regarding your participation in this research study or if you have any questions about your rights as a research subject, you should speak with the Principal Investigator, Dr. Kathryn Bowles, or the Co-Investigator, Sandra Jost: (609) 314-xxxxBowles@upenn.edu or Sgjost@upenn.edu

APPENDIX D: IMPACT OF HEALTH INFORMATION TECHNOLOGY (I-HIT)©

I-HIT Scale

General advantages of HIT	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree	NA
1. HIT applications/tools have decreased the time I need for end of shift report.							
2. HIT applications have decreased the need for direct communication around writing patient orders.							
3. HIT provides better information to prepare me for my assigned patients each day.							
4. HIT facilitates practice efficiency.							
5. HIT allows for patient/family participation in care							
6. The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone.							
7. The ability of nurses to access information electronically has improved their ability to independently make decisions.							
8. HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.							
9. Work lists generated from HIT tools support efficient patient care.							

Workflow Implications of HIT	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree	NA
1. The ways in which data/ information are displayed using HIT improves access to data.							
2. HIT depersonalizes care.							
3. The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.							
4. The availability of electronic interdisciplinary documentation has improved the capacity of dinicians to work together.							
5. HIT applications/tools support the nursing process.							
6. The ways in which data/ information are displayed using HIT reduces redundancy of care.							
7. The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.							
8. HIT applications/tools facilitate interdisciplinary treatment planning.							

Information Tools to Support Communication Tasks	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree	NA
1. My site is utilizing HIT strategies to optimize interdisciplinary communication (e.g. clinical messaging, Vocera or similar wireless voice communication system, text paging).							
2. Available HIT applications/tools facilitate the process of patient tracking.							
3. I have access to HIT applications/tools that support interdisciplinary communication when I need them.							
4. Available HIT tools support both patient care and administrative processes.							
5. HIT facilitates ID communication that is patient centered.							
6. The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.							
7. I know how to access the HIT applications/tools available in the electronic medical record system.							

Information Tools to Support Information Tasks	1 Strongly Disagree	2 Moderately Disagree	3 Slightly Disagree	4 Slightly Agree	5 Moderately Agree	6 Strongly Agree	NA
1. I find the acknowledgement features of current HIT applications/tools provide adequate assurance that my interdisciplinary colleagues have received the communications that I send							
2. I find the acknowledgement features of current HIT applications/tools provide adequate assurance that interdisciplinary colleagues have acted upon information that I send.							
3. HIT promotes 2-way communication between clinicians about patient status.							
4. Communication of critical events to interdisciplinary colleagues can be done effectively using HIT.							
5. HIT applications/tools help me to be problem-focused in my communications.							

APPENDIX E: ESSENTIALS OF MAGNETISM II (EOM II) ©

Nurse Knowledge Work / Clinical Decision Support Study

ESSENTIALS OF A HEALTHY, MAGNETIC WORK ENVIRONMENT (EOMII) ©

	Indicate the extent to which each statement is descriptive of your unit/service work environment.	**True for most MDs, most of the time**	**True for some MDs, some of the time**	**True for 1 or 2 MDs on occasion**	**Not true for any MDs**
1	Nurse-physician relationships on my unit are that of a 'student-teacher' with physicians willing to explain and teach the nurses.				
2	Nurse-physician relationships consist of willing cooperation based on *mutual* power, trust, and respect.				
3	Relationships between nurses and physicians are frustrating, hostile and characterized by 'power plays,' antagonism or resentment.				
4	Relationships with MDs are that of 'student-teacher' with RNs influencing MDs in their prescribing care for patients.				
5	Our nurse-physician relationships are rather formal and characterized mainly by the nurse responding to the physician's questions.				
6	Physicians treat nurses on this unit as *equals*. MDs need RNs' assessments/observations and RNs need MDs medical knowledge if together we are going to help the patient.				
		Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
7	Other professionals (therapists, physicians) indicate they value nurses pursuing their education, extending their knowledge, and increasing their competence				
8	Our nurse manager makes it possible for nurses on the unit to attend continuing education, outside courses and/or degree completion programs.				
9	In this organization, there are few rewards such as salary increases or promotion for pursuing one's education.				
10	This organization provides financial assistance and/or paid time off for nurses to attend educational programs.				
11	Nurses here fear 'getting into trouble' or 'taking big risks' if they make independent, autonomous decisions.				
12	Autonomous nursing practice is facilitated because nurses 'feel' or know that nurse managers will support them.				

13	Staff nurses must obtain orders or consent from an authority source before making independent or interdependent decisions.				
		Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
14	On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decisions in those spheres where nursing overlaps with other disciplines.				
15	Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions.				
16	This organization has many rules and regulations that prevent nurses from making independent or interdependent decisions.				
17	In this hospital, nurses have to do things that, in our professional judgment, may not be in the best interests of the patient.				
18	Nurses are held accountable in a positive, constructive, learning way for the outcomes of autonomous clinical nursing practice.				
19	There is a general understanding among nurses on my unit that nursing administration wants us to function autonomously.				
20	We have a Council or committee structure through which nurses on our unit and in this hospital control nursing practice.				
21	Staff nurses have input and make decisions with respect to *practice* issues and policies such as selection of equipment, how frequently to change IV line dressings, etc.				
22	Physicians, administrators, nurses and other professionals (ex. physical therapists) recognize that nursing in this hospital controls its own practice.				
23	Shared decision-making is more talk than action here; clinical (staff) nurses don't take part in decision-making.				
24	Representatives from other departments and disciplines such as transportation, pharmacy, respiratory therapy, participate in our shared decision-making activities on a regular basis.				
25	Nurses in this organization have input and make decisions related to *personnel* issues and policies that directly affect them such as floating, schedules, care delivery system.				
26	Nurses on my unit can describe decisions made and outcomes achieved as a result of our shared decision-making process.				
27	Nursing practice, policies, issues and standards are determined by nursing management, administration or people outside of nursing. Staff nurses do not have control.				
28	The nurses on my unit judge that, most of the time, we are adequately staffed to give *quality patient care*.				
29	We don't have enough competent and experienced nurses who 'know' the unit, patients and physicians to provide *safe* care.				
30	We modify our patient care delivery system (Ex. team, primary) on the basis of the number and experience of RNs available.				
31	We work as a team on our unit. We need				

	one another and need to work together if patients are to receive high quality care.				
32	Our group cohesiveness enables us to give quality care with our current level of staffing.				
33	Our unit is not a sufficient number of budgeted RN positions for the acuity of our patients. This makes if difficult to give quality patient care even when all budgeted positions are filled.				
34	Nurses on my unit demonstrate a proficiency level of competence.				
35	Nurses' competent performances are recognized and rewarded both on my unit and in this organization.				
36	Continuing education toward a nursing degree is recognized as a way in which nurses can increase their nursing competence.				
37	National certification is recognized as evidence of proficient clinical competence.				
		Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**
38	Our nurse manager represents the positions and interests of the staff and of our unit to other departments and to administration. He/she "watches our back".				
39	If we need resources such as equipment or supplies, our nurse manager sees to it that we get these.				
40	Our manager is diplomatic, fair and honest in resolving conflicts between nurses, physicians or other departments.				
41	Our nurse manager supports and encourages interdisciplinary— physicians, nurses, and other disciplines—planning and action.				
42	The nurse manager on our unit sees to it that we have adequate numbers of competent staff to get the job done.				
43	Our nurse manager cites specific examples, both positive and negative, when he/she provides us feedback.				
44	The nurse manager of our unit promotes staff cohesion and is a positive force in getting us to work together.				
45	Our manager is visible, available, approachable and 'safe'.				
46	Our manager teaches us the values of the organization regarding patient care and "puts the values into action".				
47	Our manager fosters sound decision-making by asking for 'best practice' evidence for the decisions we are making				
48	This hospital is willing to try new things.				
49	Concern for the patient is paramount on my unit and in this hospital.				
50	Problems are solved by swift action; people are not afraid to take risks.				
51	People on my unit are enthusiastic about their work				

52	High performance and productivity are expected of everyone.				
53	We work together as a team, both within nursing and with medicine and other disciplines.				
54	Cost (money) is important, but quality patient care comes first in this organization.				
55	The contributions of all members of the staff (RNs, nurse assistants, techs) are important and are valued.				
56	Our administration anticipates organizational changes that need to be made because of changes in the health care system, and sees to it that we are out in front.				
57	This is a value driven organization. Values are known, understood, shared, and frequently talked about.				
58	We make a conscious effort to transmit our cultural values to in-coming nurses, physicians, techs and assistants.				

NURSE-ASSESSED QUALITY OF PATIENT CARE ON UNIT

Circle a number that indicates the **usual quality of care provided to patients** on your unit.

0 1 2 3 4 **5** 6 7 8 9 **10**

Dangerously Low **Safe, but not much more** **Very high quality**

APPENDIX F: RN DEMOGRAPHIC DATA TOOL

Human Subject (RN) Demographic Data Collection Tool

Nurse Knowledge Work/Clinical Decision Support Study

Demographic Data Collection Form

1. Please check one box to indicate the highest level of educational degree attained

Educational Preparation	Diploma	☐	Associate	☐	Bachelor	☐
	Master	☐	Doctorate	☐	Other	☐

2. Did you obtain your nursing education outside of the United States? Please check one box

Internationally Educated	Yes	☐	No	☐

3. Please indicate the total number of years you have been a Registered Nurse:

Total # of Years of RN Experience	

4. How many years have you been a Registered Nurse at HUP?

Total # of Year as an RN at HUP	

5. ***Please indicate your current CARP clinical level. Please check one box***

Current Clinical Level	1	☐	2	☐	3	☐	4	☐

6. *Please indicate the shift you usually work. Please check one box*

Shift worked ≥ 50% of time	12 hour days	☐	12 hour nights	☐	10 hour days	☐
	8 hour days	☐	8 hour nights	☐	10 hour nights	☐
	Rotate ≥ 50% of shifts	☐				

7. Please indicate your clinical unit. Please check one box

Medical Units	Rhoads 3	☐	Rhoads 6	☐	Rhoads 7	☐
	F10/CICU	☐	F11/CICU	☐	F12	☐
	F14	☐	CCU	☐	MICU	☐
	Silver 11	☐				
Surgical Units	Silver 9 Gen	☐	Silv 9/INCU	☐	Silver 10	☐
	Silver 12	☐	Dulles 6	☐	Ravdin 6	☐
	Ravdin 9	☐	Rhoads 1	☐	Rhoads 4	☐

	RP 2 Neuro ICU	☐	RP 5 SCCC	☐	Founders 5 ICU	☐
Women's Health Units	Silver 7	☐	Silver 8	☐	PEC	☐
	L&D	☐				
Other Types of Units	Transition	☐	SFAS	☐	PICC	☐

8. Please indicate your age. Please fill in the box

Age ☐

9. Please indicate your gender. Please check one box

Gender	Male	☐	Female	☐	Transgender	☐

10. Please indicate your ethnicity. Please check one box

Ethnicity	Hispanic or Latino	☐	Not Hispanic or Latino	☐

11. Please indicate your race. Please check one box

Race

White ☐

Black or African American ☐

Asian ☐

Native Hawaiian or Other Pacific Islander ☐

American Indian/ Alaska Native ☐

12. Average hours worked per week. Please fill in the box.

Avg. hours worked/week

APPENDIX G: ITEM ANALYSIS FOR I-HIT

Table G 4.1

Reliability Item Analysis for the Impact of Health Information Technology for the Paired Sample

Items Overall Cronbach's alpha 0.936	Scale Mean if Item Deleted	Corrected Item-Total Correlation	Cronbach Alpha if Item Deleted
1.) HIT applications/tools have decreased the time I need for end of shift report.	124.0	.528	.93
2.) HIT applications have decreased the need for direct communication around writing patient orders.	123.8	.309	.94
3.) HIT provides better information to prepare me for my assigned patients each day.	123.1	.562	.93
4.) HIT facilitates practice efficiency.	122.9	.574	.93
5.) HIT allows for patient/family participation in care.	123.9	.601	.93
6.) The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone.	123.4	.509	.94
7.) The ability of nurses to access information electronically has improved their ability to independently make decisions.	123.3	.598	.93
8.) HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.	123.1	.576	.93
9.) Work lists generated from HIT tools support efficient patient care.	123.0	.636	.93
10.) The ways in which data/ information are displayed using HIT improves access to data.	122.9	.651	.93
11.) HIT depersonalizes care.	123.8	.071	.94
12.) The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.	122.9	.672	.93
13.) The availability of electronic interdisciplinary documentation has improved the capacity of clinicians to work together.	123.2	.678	.93

14.) HIT applications/tools support the nursing process.	123.1	.694	.93
15.) The ways in which data/ information are displayed using HIT reduces redundancy of care.	123.5	.553	.93
16.) The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.	123.2	.651	.93
17.) HIT applications/tools facilitate interdisciplinary treatment planning.	123.2	.703	.93
18.) My site is utilizing HIT strategies to optimize interdisciplinary communication (e.g. clinical messaging, Vocera or similar wireless voice communication system, text paging).	123.3	.456	.93
19.) Available HIT applications/tools facilitate the process of patient tracking.	122.7	.400	.93
20.) I have access to HIT applications/tools that support interdisciplinary communication when I need them.	123.0	.644	.93
21.) Available HIT tools support both patient care and administrative processes.	123.1	.673	.93
22.) HIT facilitates ID communication that is patient centered.	123.2	.632	.93
23.) The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.	123.2	.700	.93
24.) I know how to access the HIT applications/tools available in the electronic medical record system.	122.9	.295	.94
25.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that my interdisciplinary colleagues have received the communications that I send.	123.6	.596	.93
26.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that interdisciplinary colleagues have acted upon information that I send.	123.8	.630	.93
27.) HIT promotes 2-way communication between clinicians about patient status.	123.6	.653	.93
28.) Communication of critical events to interdisciplinary colleagues can be done effectively using HIT.	123.9	.629	.93
29.) HIT applications/tools help me to be problem-focused in my communications.	123.5	.695	.93

Table G 4.2
Reliability Item Analysis for Impact of Health Information Technology for the Pre-Implementation Independent Sample

Items Overall Cronbach's alpha 0.949	Scale Mean if Item Deleted	Corrected Item-Total Correlation	Cronbach Alpha if Item Deleted
1.) HIT applications/tools have decreased the time I need for end of shift report.	123.8	.501	.95
2.) HIT applications have decreased the need for direct communication around writing patient orders.	123.7	.496	.95
3.) HIT provides better information to prepare me for my assigned patients each day.	123.0	.661	.95
4.) HIT facilitates practice efficiency.	123.0	.728	.95
5.) HIT allows for patient/family participation in care.	124.0	.530	.95
6.) The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone.	123.5	.565	.95
7.) The ability of nurses to access information electronically has improved their ability to independently make decisions.	123.3	.648	.95
8.) HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.	123.1	.675	.95
9.) Work lists generated from HIT tools support efficient patient care.	123.0	.711	.95
10.) The ways in which data/ information are displayed using HIT improves access to data.	123.0	.722	.95
11.) HIT depersonalizes care.	123.9	.093	.95
12.) The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.	122.9	.637	.95
13.) The availability of electronic interdisciplinary documentation has improved the capacity of clinicians to work together.	123.1	.703	.95

14.) HIT applications/tools support the nursing process.	123.1	.782	.95
15.) The ways in which data/ information are displayed using HIT reduces redundancy of care.	123.5	.532	.95
16.) The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.	123.0	.709	.95
17.) HIT applications/tools facilitate interdisciplinary treatment planning.	122.9	.745	.95
18.) My site is utilizing HIT strategies to optimize interdisciplinary communication (e.g. clinical messaging, Vocera or similar wireless voice communication system, text paging).	123.2	.503	.95
19.) Available HIT applications/tools facilitate the process of patient tracking.	122.8	.504	.95
20.) I have access to HIT applications/tools that support interdisciplinary communication when I need them.	123.1	.750	.95
21.) Available HIT tools support both patient care and administrative processes.	123.2	.761	.95
22.) HIT facilitates ID communication that is patient centered.	123.1	.761	.95
23.) The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.	123.2	.663	.95
24.) I know how to access the HIT applications/tools available in the electronic medical record system.	122.8	.436	.95
25.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that my interdisciplinary colleagues have received the communications that I send.	123.6	.641	.95
26.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that interdisciplinary colleagues have acted upon information that I send.	123.7	.670	.95
27.) HIT promotes 2-way communication between clinicians about patient status.	123.4	.599	.95
28.) Communication of critical events to interdisciplinary colleagues can be done effectively using HIT.	123.6	.527	.95
29.) HIT applications/tools help me to be problem-focused in my communications.	123.4	.726	.95

Table G 4.3

Reliability Item Analysis for the Impact of Health Information Technology Post-Implementation Independent Sample

Items Overall Cronbach's alpha 0.968	Scale Mean if Item Deleted	Corrected Item-Total Correlation	Cronbach Alpha if Item Deleted
1.) HIT applications/tools have decreased the time I need for end of shift report.	114.1	.570	.97
2.) HIT applications have decreased the need for direct communication around writing patient orders.	113.6	.526	.97
3.) HIT provides better information to prepare me for my assigned patients each day.	113.1	.796	.97
4.) HIT facilitates practice efficiency.	113.3	.821	.97
5.) HIT allows for patient/family participation in care.	114.0	.705	.97
6.) The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone.	113.5	.578	.97
7.) The ability of nurses to access information electronically has improved their ability to independently make decisions.	113.2	.692	.97
8.) HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.	113.2	.745	.97
9.) Work lists generated from HIT tools support efficient patient care.	113.1	.786	.97
10.) The ways in which data/ information are displayed using HIT improves access to data.	113.1	.774	.97
11.) HIT depersonalizes care.	113.9	.380	.97
12.) The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.	113.1	.815	.97
13.) The availability of electronic interdisciplinary documentation has improved the capacity of clinicians to work together.	113.2	.804	.97
14.) HIT applications/tools support the nursing process.	113.2	.816	.97

15.) The ways in which data/ information are displayed using HIT reduces redundancy of care.	113.8	.737	.97
16.) The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.	113.1	.784	.97
17.) HIT applications/tools facilitate interdisciplinary treatment planning.	113.1	.808	.97
18.) My site is utilizing HIT strategies to optimize interdisciplinary communication (e.g. clinical messaging, Vocera or similar wireless voice communication system, text paging).	113.2	.633	.97
19.) Available HIT applications/tools facilitate the process of patient tracking.	112.5	.577	.97
20.) I have access to HIT applications/tools that support interdisciplinary communication when I need them.	112.8	.597	.97
21.) Available HIT tools support both patient care and administrative processes.	113.1	.835	.97
22.) HIT facilitates ID communication that is patient centered.	113.1	.816	.97
23.) The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.	113.2	.819	.97
24.) I know how to access the HIT applications/tools available in the electronic medical record system.	112.4	.267	.97
25.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that my interdisciplinary colleagues have received the communications that I send.	113.5	.708	.97
26.) I find the acknowledgement features of current HIT applications/tools provide adequate assurance that interdisciplinary colleagues have acted upon information that I send.	113.7	.715	.97
27.) HIT promotes 2-way communication between clinicians about patient status.	113.6	.741	.97
28.) Communication of critical events to interdisciplinary colleagues can be done effectively using HIT.	113.8	.716	.97
29.) HIT applications/tools help me to be problem-focused in my communications.	113.4	.811	.97

APPENDIX H: I-HIT SUBSCALE INTERCORRELATION MATRIXES

Table H 4.1

Subscale Intercorrelation Matrix of Impact of Health Information Technology Scale (I-HIT) for Paired Sample Pre-Intervention Group

		General Advantages of HIT	Work Flow Implications of HIT	Information Tools to Support Communication Tasks	Information Tools to Support Information Tasks	HIT Depersonalizes Care
General Advantages of HIT	r	1				
	Sig. (2-tailed)					
	N	434				
Work Flow Implications of HIT	r	.704**	1			
	Sig. (2-tailed)	.000				
	N	430	433			
Information Tools to Support Communication Tasks	r	.555**	.696**	1		
	Sig. (2-tailed)	.000	.000			
	N	433	433	439		
Information Tools to Support Information Tasks	r	.520**	.646**	.545**	1	
	Sig. (2-tailed)	.000	.000	.000		
	N	426	429	430	430	
HIT Depersonalizes Care	r	.080	.154**	.137**	-.009	1
	Sig. (2-tailed)	.100	.001	.004	.854	
	N	425	426	427	422	428

r =Pearson's Correlation Coefficient

**Correlation is significant at the 0.01 level (2-tailed).

Table H 4.2

Subscale Intercorrelation Matrix of Impact of Health Information Technology Scale (I-HIT) for Paired Sample Post-Intervention Group

		General Advantages of HIT	Work Flow Implications of HIT	Information Tools to Support Communication Tasks	Information Tools to Support Information Tasks	HIT Depersonalizes Care
General Advantages of HIT	r	1				
	Sig.					
	N	458				
Work Flow Implications of HIT	r	.861**	1			
	Sig.	.000				
	N	458	458			
Information Tools to Support	r	.756**	.806**	1		
Communication Tasks	Sig.	.000	.000			
	N	457	457	457		
Information Tools to Support	r	.692**	.751**	.686**	1	
Information Tasks	Sig.	.000	.000	.000		
	N	454	454	454	454	
HIT Depersonalizes Care	r	.424**	.439**	.393**	.316**	1
	Sig.	.000	.000	.000	.000	
	N	451	451	451	449	451

r =Pearson's Correlation Coefficient

**Correlation is significant at the 0.01 level (2-tailed).

Table H 4.3

Subscale Intercorrelation Matrix of Impact of Health Information Technology Scale (I-HIT) for Independent Sample Pre-Only Group

		General Advantages of HIT	Work Flow Implications of HIT	Information Tools to Support Communication Tasks	Information Tools to Support Information Tasks	HIT Depersonalizes Care
General Advantages of HIT	r	1				
	Sig.					
	N	238				
Work Flow Implications of HIT	r	.731**	1			
	Sig	.000				
	N	236	240			
Information Tools to Support	r	.585**	.679**	1		
Communication Tasks	Sig	.000	.000			
	N	235	238	238		
Information Tools to Support	r	.574**	.642**	.566**	1	
Information Tasks	Sig	.000	.000	.000		
	N	233	235	234	235	
HIT Depersonalizes Care	r	.068	.144*	.176**	-.011	1
	Sig.	.305	.029	.008	.874	
	N	231	231	230	229	231

r =Pearson's Correlation Coefficient

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table H 4.4

Subscale Intercorrelation Matrix of Impact of Health Information Technology Scale (I-HIT) Independent Sample Post-Only Group

		General Advantages of HIT	Work Flow Implications of HIT	Information Tools to Support Communication Tasks	Information Tools to Support Information Tasks	HIT Depersonalizes Care
General Advantages of HIT	r	1				
	Sig. (2-tailed)					
	N	333				
Work Flow Implications of HIT	r	.860**	1			
	Sig. (2-tailed)	.000				
	N	332	332			
Information Tools to Support Communication Tasks	r	.720**	.782**	1		
	Sig. (2-tailed)	.000	.000			
	N	330	330	330		
Information Tools to Support Information Tasks	r	.668**	.671**	.672**	1	
	Sig. (2-tailed)	.000	.000	.000		
	N	323	323	323	323	
HIT Depersonalizes Care	r	.298**	.331**	.276**	.172**	1
	Sig. (2-tailed)	.000	.000	.000	.002	
	N	327	327	327	321	328

r =Pearson's Correlation Coefficient

** Correlation is significant at the 0.01 level (2-tailed).

APPENDIX I: PRE- and- POST MEAN DIFFERENCE SCORES FOR I-HIT ITEMS

Table I 4.1

Pre- and-Post-Mean Difference Scores of I-HIT Items for the Paired Sample

Item #	I-HIT Item	Pre-Mean	Post-Mean	Difference*
4	HIT facilitates practice efficiency.	4.64	3.68	0.96
15	The ways in which data/ information are displayed using HIT reduces redundancy of care.	4.10	3.17	0.93
10	The ways in which data/ information are displayed using HIT improves access to data.	4.72	3.85	0.87
3	HIT provides better information to prepare me for my assigned patients each day.	4.67	3.94	0.73
1	HIT applications/tools have decreased the time I need for end of shift report.	3.69	2.97	0.72
9	Work lists generated from HIT tools support efficient patient care.	4.67	3.96	0.71
14	HIT applications/tools support the nursing process.	4.52	3.86	0.66
11	HIT depersonalizes care*	3.99	3.38	0.61
5	HIT allows for patient/family participation in care.	3.66	3.07	0.59
16	The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.	4.41	3.83	0.58
13	The availability of electronic interdisciplinary documentation has improved the capacity of clinicians to work together.	4.42	3.84	0.58
12	The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.	4.75	4.18	0.57
2	HIT applications have decreased the need for direct communication around writing patient orders.	3.96	3.39	0.57
7	The ability of nurses to access information electronically has improved their ability to independently make decisions.	4.30	3.75	0.55

23	The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.	4.40	3.87	0.53
8	HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.	4.54	4.05	0.49
17	HIT applications/tools facilitate interdisciplinary treatment planning.	4.41	3.92	0.49
6	The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone.	4.15	3.68	0.47
21	Available HIT tools support both patient care and administrative processes.	4.51	4.05	0.46
22	HIT facilitates ID communication that is patient centered.	4.47	4.04	0.43
19	Available HIT applications/tools facilitate the process of patient tracking.	5.00	4.59	0.41
28	Communication of critical events to interdisciplinary colleagues can be done effectively using HIT.	3.61	3.20	0.41
25	I find the acknowledgement features of current HIT applications/tools provide adequate assurance that my interdisciplinary colleagues have received the communications that I send.	4.01	3.60	0.41
27	HIT promotes 2-way communication between clinicians about patient status.	3.92	3.53	0.39
29	HIT applications/tools help me to be problem-focused in my communications.	4.07	3.70	0.37
26	I find the acknowledgement features of current HIT applications/tools provide adequate assurance that interdisciplinary colleagues have acted upon information that I send.	3.83	3.50	0.33
18	My site is utilizing HIT strategies to optimize interdisciplinary communication (e.g. clinical messaging, Vocera or similar wireless voice communication system, text paging).	4.33	4.01	0.32
20	I have access to HIT applications/tools that support interdisciplinary communication when I need them.	4.58	4.33	0.25
24	I know how to access the HIT applications/tools available in the electronic medical record system.	4.80	4.97	-0.17

* Difference = (Pre-Mean –Post-Mean)

Table I 4.2

Pre- and-Post Mean Difference Scores of I-HIT Items for the Independent Sample

Item #	I-HIT Item	Pre-Mean	Post-Mean	Difference*
4	HIT facilitates practice efficiency.	4.72	4.02	0.70
1	HIT applications/tools have decreased the time I need for end of shift report.	3.89	3.21	0.68
15	The ways in which data/ information are displayed using HIT reduces redundancy of care	4.09	3.49	0.60
3	HIT provides better information to prepare me for my assigned patients each day.	4.76	4.23	0.53
28	Communication of critical events to interdisciplinary colleagues can be done effectively using HIT.	4.00	3.48	0.52
8	HIT applications available at my facility improve my ability to assume care for patients transferring into my unit.	4.62	4.11	0.51
14	HIT applications/tools support the nursing process.	4.60	4.09	0.51
12	The HIT applications available at my site help me to process data and therefore improve access to information necessary to provide safe patient care.	4.74	4.27	0.47
9	Work lists generated from HIT tools support efficient patient care.	4.68	4.21	0.47
10	The ways in which data/ information are displayed using HIT improves access to data.	4.70	4.25	0.45
5	HIT allows for patient/family participation in care.	3.68	3.24	0.44
17	HIT applications/tools facilitate interdisciplinary treatment planning.	4.66	4.23	0.43
27	HIT promotes 2-way communication between clinicians about patient status.	4.18	3.76	0.42
29	HIT applications/tools help me to be problem-focused in my communications.	4.25	3.87	0.38
13	The availability of electronic interdisciplinary documentation has improved the capacity of clinicians to work together.	4.51	4.14	0.37

18	My site is utilizing HIT strategies to optimize interdisciplinary communication (e.g. clinical messaging, Vocera or similar wireless voice communication system, text paging).	4.40	4.05	0.35
23	The availability of information afforded by HIT at my site helps nurses collaborate at a higher level with interdisciplinary colleagues than was possible with paper systems.	4.46	4.11	0.35
22	HIT facilitates ID communication that is patient centered.	4.55	4.24	0.31
16	The ways in which data/ information are displayed using HIT facilitates interdisciplinary care planning.	4.53	4.23	0.30
26	I find the acknowledgement features of current HIT applications/tools provide adequate assurance that interdisciplinary colleagues have acted upon information that I send.	4.00	3.71	0.29
21	Available HIT tools support both patient care and administrative processes.	4.52	4.24	0.28
11	HIT depersonalizes care*	3.82	3.57	0.25
6	The ability of interdisciplinary team members to access information electronically has reduced their need to communicate directly with each other face-to-face or via phone.	4.09	3.86	0.23
25	I find the acknowledgement features of current HIT applications/tools provide adequate assurance that my interdisciplinary colleagues have received the communications that I send.	4.08	3.86	0.22
7	The ability of nurses to access information electronically has improved their ability to independently make decisions.	4.33	4.12	0.21
19	Available HIT applications/tools facilitate the process of patient tracking.	4.96	4.81	0.15
2	HIT applications have decreased the need for direct communication around writing patient orders.	3.93	3.79	0.14
20	I have access to HIT applications/tools that support interdisciplinary communication when I need them.	4.62	4.50	0.12
24	I know how to access the HIT applications/tools available in the electronic medical record system.	4.72	4.91	-0.19

* Difference = (Pre-Mean –Post-Mean)

APPENDIX J: PRE- and -POST MEAN DIFFERENCE SCORES FOR EOM II ITEMS

Table J 4.1

Pre-and-Post Mean Difference Scores of EOM II Items for the Paired Sample

Item #	I-HIT Item	Pre-Mean	Post-Mean	Difference*
34	Nurses on my unit demonstrate a proficiency level of competence.	3.28	3.27	0.01
55	The contributions of all members of the staff (RNs, nurse assistants, techs) are important and are valued.	3.19	3.18	0.01
49	Concern for the patient is paramount on my unit and in this hospital.	3.35	3.35	0.00
40	Our manager is diplomatic, fair and honest in resolving conflicts between nurses, physicians or other departments.	2.99	3.00	-0.01
43	Our nurse manager cites specific examples, both positive and negative, when he/she provides us feedback.	3.00	3.01	-0.01
51	People on my unit are enthusiastic about their work	2.80	2.81	-0.01
2	Nurse-physician relationships consist of willing cooperation based on mutual power, trust, and respect.	3.21	3.23	-0.02
46	Our manager teaches us the values of the organization regarding patient care and "puts the values into action".	3.04	3.07	-0.03
36	Continuing education toward a nursing degree is recognized as a way in which nurses can increase their nursing competence.	3.16	3.19	-0.03
23	Shared decision-making is more talk than action here; clinical (staff) nurses don't take part in decision-making*.	2.75	2.78	-0.03
41	Our nurse manager supports and encourages interdisciplinary-physicians, nurses, and other disciplines-planning and action.	3.18	3.21	-0.03
45	Our manager is visible, available, approachable and 'safe'.	3.08	3.11	-0.03
31	We work as a team on our unit. We need one another and need to work together if patients are to receive high quality care.	3.43	3.46	-0.03
14	On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decisions in those spheres where nursing overlaps with other disciplines.	3.10	3.13	-0.03

52	High performance and productivity are expected of everyone.	3.33	3.36	-0.03
6	Physicians treat nurses on this unit as equals. MDs need RNs' assessments/observations and RNs need MDs medical knowledge if together we are going to help the patient.	3.23	3.26	-0.03
44	The nurse manager of our unit promotes staff cohesion and is a positive force in getting us to work together.	2.93	2.96	-0.03
47	Our manager fosters sound decision-making by asking for 'best practice' evidence for the decisions we are making.	3.07	3.10	-0.03
8	Our nurse manager makes it possible for nurses on the unit to attend continuing education, outside courses and/or degree completion programs.	3.36	3.39	-0.03
17	In this hospital, nurses have to do things that, in our professional judgment, may not be in the best interests of the patient*.	2.85	2.89	-0.04
39	If we need resources such as equipment or supplies, our nurse manager sees to it that we get these.	3.10	3.14	-0.04
27	Nursing practice, policies, issues and standards are determined by nursing management, administration or people outside of nursing. Staff nurses do not have control*.	2.68	2.72	-0.04
28	The nurses on my unit judge that, most of the time, we are adequately staffed to give quality patient care.	2.67	2.71	-0.04
50	Problems are solved by swift action; people are not afraid to take risks.	2.72	2.77	-0.05
56	Our administration anticipates organizational changes that need to be made because of changes in the health care system, and sees to it that we are out in front.	2.99	3.04	-0.05
33	Our unit is not a sufficient number of budgeted RN positions for the acuity of our patients. This makes it difficult to give quality patient care even when all budgeted positions are filled*.	2.60	2.65	-0.05
30	We modify our patient care delivery system (Ex. team, primary) on the basis of the number and experience of RNs available.	2.63	2.68	-0.05
3	Relationships between nurses and physicians are frustrating, hostile and characterized by 'power plays,' antagonism or resentment*.	3.09	3.14	-0.05
54	Cost (money) is important, but quality patient care comes first in this organization.	2.84	2.89	-0.05
32	Our group cohesiveness enables us to give quality care with our current level of staffing.	3.17	3.22	-0.05
58	We make a conscious effort to transmit our cultural values to in-coming nurses, physicians, techs and assistants.	3.07	3.12	-0.05

37	National certification is recognized as evidence of proficient clinical competence.	3.26	3.31	-0.05
29	We don't have enough competent and experienced nurses who 'know' the unit, patients and physicians to provide safe care*.	3.01	3.06	-0.05
10	This organization provides financial assistance and/or paid time off for nurses to attend educational programs.	3.20	3.26	-0.06
1	Nurse-physician relationships on my unit are that of a 'student-teacher' with physicians willing to explain and teach the nurses.	3.00	3.06	-0.06
15	Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions.	3.15	3.21	-0.06
48	This hospital is willing to try new things.	3.10	3.16	-0.06
4	Relationships with MDs are that of 'student-teacher' with RNs influencing MDs in their prescribing care for patients.	2.77	2.84	-0.07
24	Representatives from other departments and disciplines such as transportation, pharmacy, respiratory therapy, participate in our shared decision-making activities on a regular basis.	2.68	2.75	-0.07
11	Nurses here fear 'getting into trouble' or 'taking big risks' if they make independent, autonomous decisions*.	2.68	2.75	-0.07
18	Nurses are held accountable in a positive, constructive, learning way for the outcomes of autonomous clinical nursing practice.	2.94	3.01	-0.07
57	This is a value driven organization. Values are known, understood, shared, and frequently talked about.	3.03	3.10	-0.07
59	Circle a number that indicates the usual quality of care provided to patients on your unit.	8.37	8.44	-0.07
9	In this organization, there are few rewards such as salary increases or promotion for pursuing one's education*.	2.49	2.57	-0.08
53	We work together as a team, both within nursing and with medicine and other disciplines.	3.18	3.26	-0.08
38	Our nurse manager represents the positions and interests of the staff and of our unit to other departments and to administration. He/she "watches our back".	2.92	3.00	-0.08
16	This organization has many rules and regulations that prevent nurses from making independent or interdependent decisions*.	2.70	2.80	-0.10
12	Autonomous nursing practice is facilitated because nurses 'feel' or know that nurse managers will support them.	2.73	2.83	-0.10

20	We have a council or committee structure through which nurses on our unit and in this hospital control nursing practice.	3.10	3.20	-0.10
26	Nurses on my unit can describe decisions made and outcomes achieved as a result of our shared decision-making process.	2.88	2.98	-0.10
35	Nurses' competent performances are recognized and rewarded both on my unit and in this organization.	2.80	2.90	-0.10
25	Nurses in this organization have input and make decisions related to personnel issues and policies that directly affect them such as floating, schedules, care delivery system.	2.68	2.79	-0.11
13	Staff nurses must obtain orders or consent from an authority source before making independent or interdependent decisions*.	2.27	2.39	-0.12
19	There is a general understanding among nurses on my unit that nursing administration wants us to function autonomously.	2.65	2.78	-0.13
42	The nurse manager on our unit sees to it that we have adequate numbers of competent staff to get the job done.	2.89	3.02	-0.13
22	Physicians, administrators, nurses and other professionals (ex. physical therapists) recognize that nursing in this hospital controls its own practice.	2.74	2.89	-0.15
7	Other professionals (therapists, physicians) indicate they value nurses pursuing their education, extending their knowledge, and increasing their competence.	3.05	3.20	-0.15
21	Staff nurses have input and make decisions with respect to practice issues and policies such as selection of equipment, how frequently to change IV line dressings, etc.	2.91	3.07	-0.16
5	Our nurse-physician relationships are rather formal and characterized mainly by the nurse responding to the physician's questions*.	2.75	2.94	-0.19

* Difference = (Pre-Mean –Post-Mean)

Table J 4.2

Pre-and-Post Mean Difference Scores of EOM II Items for the Independent Sample

Item #	I-HIT Item	Pre-Mean	Post-Mean	Difference*
1	Nurse-physician relationships on my unit are that of a 'student-teacher' with physicians willing to explain and teach the nurses.	3.06	2.99	0.07
2	Nurse-physician relationships consist of willing cooperation based on mutual power, trust, and respect.	3.22	3.16	0.06
7	Other professionals (therapists, physicians) indicate they value nurses pursuing their education, extending their knowledge, and increasing their competence.	3.19	3.13	0.06
41	Our nurse manager supports and encourages interdisciplinary-physicians, nurses, and other disciplines-planning and action.	3.22	3.20	0.02
55	The contributions of all members of the staff (RNs, nurse assistants, techs) are important and are valued.	3.18	3.16	0.02
43	Our nurse manager cites specific examples, both positive and negative, when he/she provides us feedback.	3.03	3.02	0.01
31	We work as a team on our unit. We need one another and need to work together if patients are to receive high quality care.	3.44	3.44	0.00
32	Our group cohesiveness enables us to give quality care with our current level of staffing.	3.20	3.21	-0.01
42	The nurse manager on our unit sees to it that we have adequate numbers of competent staff to get the job done.	3.02	3.03	-0.01
54	Cost (money) is important, but quality patient care comes first in this organization.	2.90	2.91	-0.01
44	The nurse manager of our unit promotes staff cohesion and is a positive force in getting us to work together.	3.05	3.06	-0.01
14	On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decisions in those spheres where nursing overlaps with other disciplines.	3.14	3.16	-0.02
39	If we need resources such as equipment or supplies, our nurse manager sees to it that we get these.	3.08	3.10	-0.02
15	Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions.	3.21	3.23	-0.02
51	People on my unit are enthusiastic about their work	2.86	2.88	-0.02

4	Relationships with MDs are that of 'student-teacher' with RNs influencing MDs in their prescribing care for patients.	2.85	2.87	-0.02
47	Our manager fosters sound decision-making by asking for 'best practice' evidence for the decisions we are making.	3.08	3.11	-0.03
30	We modify our patient care delivery system (Ex. team, primary) on the basis of the number and experience of RNs available.	2.67	2.71	-0.04
11	Nurses here fear 'getting into trouble' or 'taking big risks' if they make independent, autonomous decisions*.	2.76	2.80	-0.04
5	Our nurse-physician relationships are rather formal and characterized mainly by the nurse responding to the physician's questions*.	2.67	2.71	-0.04
28	The nurses on my unit judge that, most of the time, we are adequately staffed to give quality patient care.	2.68	2.72	-0.04
53	We work together as a team, both within nursing and with medicine and other disciplines.	3.18	3.22	-0.04
45	Our manager is visible, available, approachable and 'safe'.	3.10	3.15	-0.05
37	National certification is recognized as evidence of proficient clinical competence.	3.23	3.28	-0.05
12	Autonomous nursing practice is facilitated because nurses 'feel' or know that nurse managers will support them.	2.77	2.82	-0.05
52	High performance and productivity are expected of everyone.	3.33	3.38	-0.05
22	Physicians, administrators, nurses and other professionals (ex. physical therapists) recognize that nursing in this hospital controls its own practice.	2.78	2.83	-0.05
6	Physicians treat nurses on this unit as equals. MDs need RNs' assessments/observations and RNs need MDs medical knowledge if together we are going to help the patient.	3.21	3.27	-0.06
26	Nurses on my unit can describe decisions made and outcomes achieved as a result of our shared decision-making process.	2.92	2.98	-0.06
40	Our manager is diplomatic, fair and honest in resolving conflicts between nurses, physicians or other departments.	3.00	3.06	-0.06
19	There is a general understanding among nurses on my unit that nursing administration wants us to function autonomously.	2.75	2.81	-0.06
23	Shared decision-making is more talk than action here; clinical (staff) nurses don't take part in decision-making*.	2.78	2.84	-0.06

59	Circle a number that indicates the usual quality of care provided to patients on your unit.	8.43	8.49	-0.06
34	Nurses on my unit demonstrate a proficiency level of competence.	3.29	3.36	-0.07
46	Our manager teaches us the values of the organization regarding patient care and "puts the values into action".	3.04	3.11	-0.07
8	Our nurse manager makes it possible for nurses on the unit to attend continuing education, outside courses and/or degree completion programs.	3.31	3.39	-0.08
18	Nurses are held accountable in a positive, constructive, learning way for the outcomes of autonomous clinical nursing practice.	2.94	3.02	-0.08
38	Our nurse manager represents the positions and interests of the staff and of our unit to other departments and to administration. He/she "watches our back".	2.91	3.00	-0.09
29	We don't have enough competent and experienced nurses who 'know' the unit, patients and physicians to provide safe care*.	3.00	3.09	-0.09
16	This organization has many rules and regulations that prevent nurses from making independent or interdependent decisions*.	2.66	2.75	-0.09
25	Nurses in this organization have input and make decisions related to personnel issues and policies that directly affect them such as floating, schedules, care delivery system.	2.72	2.82	-0.10
9	In this organization, there are few rewards such as salary increases or promotion for pursuing one's education*.	2.45	2.55	-0.10
24	Representatives from other departments and disciplines such as transportation, pharmacy, respiratory therapy, participate in our shared decision-making activities on a regular basis.	2.73	2.83	-0.10
57	This is a value driven organization. Values are known, understood, shared, and frequently talked about.	3.04	3.14	-0.10
49	Concern for the patient is paramount on my unit and in this hospital.	3.26	3.36	-0.10
20	We have a council or committee structure through which nurses on our unit and in this hospital control nursing practice.	3.14	3.25	-0.11
33	Our unit is not a sufficient number of budgeted RN positions for the acuity of our patients. This makes it difficult to give quality patient care even when all budgeted positions are filled*.	2.59	2.70	-0.11
13	Staff nurses must obtain orders or consent from an authority source before making independent or interdependent decisions*.	2.23	2.35	-0.12
58	We make a conscious effort to transmit our cultural values to in-coming nurses, physicians, techs and assistants.	3.04	3.16	-0.12

21	Staff nurses have input and make decisions with respect to practice issues and policies such as selection of equipment, how frequently to change IV line dressings, etc.	2.96	3.08	-0.12
56	Our administration anticipates organizational changes that need to be made because of changes in the health care system, and sees to it that we are out in front.	2.98	3.11	-0.13
36	Continuing education toward a nursing degree is recognized as a way in which nurses can increase their nursing competence.	3.12	3.25	-0.13
48	This hospital is willing to try new things.	3.07	3.21	-0.14
3	Relationships between nurses and physicians are frustrating, hostile and characterized by 'power plays,' antagonism or resentment*.	2.96	3.11	-0.15
50	Problems are solved by swift action; people are not afraid to take risks.	2.68	2.83	-0.15
27	Nursing practice, policies, issues and standards are determined by nursing management, administration or people outside of nursing. Staff nurses do not have control*.	2.59	2.74	-0.15
17	In this hospital, nurses have to do things that, in our professional judgment, may not be in the best interests of the patient*.	2.76	2.91	-0.15
35	Nurses' competent performances are recognized and rewarded both on my unit and in this organization.	2.82	2.98	-0.16
10	This organization provides financial assistance and/or paid time off for nurses to attend educational programs.	3.13	3.29	-0.16

* Difference = (Pre-Mean –Post-Mean)

APPENDIX K: EOM II SUBSCALE INTERCORRELATION MATRIXES

Table K 4.1

Subscale Intercorrelation Matrix of Essentials of Magnetism II for Paired Sample Pre-Implementation Group

		RNMD	SuppED	Auto	CNP	Staff	CCP	NMS	PCV	PPS	QoC
Nurse-Physician Relationships (RNMD)	r	1									
	Sig.										
Support for Education (SuppED)	r	.357**	1								
	Sig.	.000									
Clinical Autonomy (Auto)	r	.428**	.410**	1							
	Sig.	.000	.000								
Control over Nursing Practice (CNP)	r	.308**	.416**	.646**	1						
	Sig.	.000	.000	.000							
Perceived Adequacy of Staffing (Staff)	r	.301**	.366**	.468**	.425**	1					
	Sig.	.000	.000	.000	.000						
Working w/ Clinically Competent Peers (CCP)	r	.336**	.537**	.482**	.534**	.534**	1				
	Sig.	.000	.000	.000	.000	.000					
Nurse Manager Support Index (NMS)	r	.297**	.557**	.640**	.550**	.560**	.613**	1			
	Sig.	.000	.000	.000	.000	.000	.000				
Patient-Centered Cultural Values (PCV)	r	.449**	.494**	.603**	.593**	.615**	.687**	.601**	1		
	Sig.	.000	.000	.000	.000	.000	.000	.000			
Professional Practice Satisfaction-Total EOM II (PPS)	r	.594**	.592**	.869**	.829**	.634**	.695**	.783**	.797**	1	
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000		
Nurse-Assessed Quality of Patient Care on Unit (QoC)	r	.303**	.316**	.327**	.295**	.598**	.449**	.415**	.483**	.470**	1
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000	

r =Pearson's Correlation Coefficient
**Correlation is significant at the 0.01 level (2-tailed).

Table K 4.2

Subscale Intercorrelation Matrix of Essentials of Magnetism II for Paired Sample Post-Implementation Group

		RNMD	SuppED	Auto	CNP	Staff	CCP	NMS	PCV	PPS	Qoc
Nurse-Physician Relationships (RNMD)	r	1									
	Sig.										
Support for Education (SuppED)	r	.361**	1								
	Sig.	.000									
Clinical Autonomy (Auto)	r	.383**	.512**	1							
	Sig.	.000	.000								
Control over Nursing Practice (CNP)	r	.316**	.549**	.716**	1						
	Sig.	.000	.000	.000							
Perceived Adequacy of Staffing (Staff)	r	.223**	.399**	.471**	.404**	1					
	Sig.	.000	.000	.000	.000						
Working w/ Clinically Competent Peers (CCP)	r	.246**	.585**	.572**	.582**	.511**	1				
	Sig.	.000	.000	.000	.000	.000					
Nurse Manager Support Index (NMS)	r	.250**	.540**	.642**	.627**	.486**	.578**	1			
	Sig.	.000	.000	.000	.000	.000	.000				
Patient-Centered Cultural Values (PCV)	r	.315**	.538**	.646**	.669**	.570**	.693**	.634**	1		
	Sig.	.000	.000	.000	.000	.000	.000	.000			
Professional Practice Satisfaction-Total EOM II (PPS)	r	.556**	.668**	.885**	.872**	.584**	.704**	.784**	.801**	1	
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000		
Nurse-Assessed Quality of Patient Care on Unit (QoC)	r	.262**	.287**	.399**	.383**	.531**	.445**	.404**	.491**	.498**	1
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000	

r =Pearson's Correlation Coefficient
** Correlation is significant at the 0.01 level (2-tailed).

Table K 4.3

Subscale Intercorrelation Matrix of Essentials of Magnetism II for Independent Sample Pre-Implementation Group

		RNMD	SuppED	Auto	CNP	Staff	CCP	NMS	PCV	PPS	Qoc
Nurse-Physician Relationships (RNMD)	r	1									
	Sig.										
Support for Education (SuppED)	r	.380**	1								
	Sig.	.000									
Clinical Autonomy (Auto)	r	.460**	.437**	1							
	Sig.	.000	.000								
Control over Nursing Practice (CNP)	r	.405**	.501**	.609**	1						
	Sig.	.000	.000	.000							
Perceived Adequacy of Staffing (Staff)	r	.382**	.445**	.437**	.520**	1					
	Sig.	.000	.000	.000	.000						
Working w/ Clinically Competent Peers (CCP)	r	.347**	.473**	.417**	.455**	.509**	1				
	Sig.	.000	.000	.000	.000	.000					
Nurse Manager Support Index (NMS)	r	.357**	.525**	.606**	.558**	.543**	.577**	1			
	Sig.	.000	.000	.000	.000	.000	.000				
Patient-Centered Cultural Values (PCV)	r	.441**	.425**	.508**	.647**	.591**	.576**	.627**	1		
	Sig.	.000	.000	.000	.000	.000	.000	.000			
Professional Practice Satisfaction-Total EOM II (PPS)	r	.672**	.617**	.835**	.842**	.662**	.621**	.776**	.774**	1	
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000		
Nurse-Assessed Quality of Patient Care on Unit (QoC)	r	.363**	.221**	.296**	.276**	.473**	.360**	.365**	.464**	.440**	1
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000	

r =Pearson's Correlation Coefficient

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table K 4.4

Subscale Intercorrelation Matrix of Essentials of Magnetism II for Independent Sample Post-Implementation Group

		RNMD	SuppED	Auto	CNP	Staff	CCP	NMS	PCV	PPS	QoC
Nurse-Physician Relationships (RNMD)	r	1									
	Sig.										
Support for Education (SuppED)	r	.383**	1								
	Sig.	.000									
Clinical Autonomy (Auto)	r	.409**	.535**	1							
	Sig.	.000	.000								
Control over Nursing Practice (CNP)	r	.356**	.560**	.679**	1						
	Sig.	.000	.000	.000							
Perceived Adequacy of Staffing (Staff)	r	.252**	.394**	.579**	.501**	1					
	Sig.	.000	.000	.000	.000						
Working w/ Clinically Competent Peers (CCP)	r	.291**	.494**	.603**	.626**	.605**	1				
	Sig.	.000	.000	.000	.000	.000					
Nurse Manager Support Index (NMS)	r	.239**	.559**	.688**	.633**	.526**	.634**	1			
	Sig.	.000	.000	.000	.000	.000	.000				
Patient-Centered Cultural Values (PCV)	r	.320**	.500**	.622**	.671**	.600**	.664**	.651**	1		
	Sig.	.000	.000	.000	.000	.000	.000	.000			
Professional Practice Satisfaction-Total EOM II (PPS)	r	.575**	.669**	.883**	.864**	.664**	.738**	.799**	.793**	1	
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000		
Nurse-Assessed Quality of Patient Care on Unit (QoC)	r	.232**	.272**	.367**	.330**	.508**	.404**	.297**	.431**	.432**	1
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000	.000	

r =Pearson's Correlation Coefficient
**Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

APPENDIX L: ITEM ANALYSIS FOR EOM II

Table L 4.1

Reliability Item Analysis of Essentials of Magnetism II for Paired Sample

Items Overall Cronbach's alpha 0.951	Scale Mean if Item Deleted	Corrected Item-Total Correlation	CronbachAlpha if Item Deleted
1) Nurse-physician relationships on my unit are that of a 'student-teacher' with physicians willing to explain and teach the nurses.	176.8	.283	.950
2) Nurse-physician relationships consist of willing cooperation based on *mutual* power, trust, and respect.	176.6	.448	.951
3) Relationships between nurses and physicians are frustrating, hostile and characterized by 'power plays,' antagonism or resentment*.	176.8	.334	.951
4) Relationships with MDs are that of 'student-teacher' with RNs influencing MDs in their prescribing care for patients.	177.1	.133	.950
5) Our nurse-physician relationships are rather formal and characterized mainly by the nurse responding to the physician's questions*.	177.1	.192	.951
6) Physicians treat nurses on this unit as *equals.* MDs need RNs' assessments/observations and RNs need MDs medical knowledge if together we are going to help the patient.	176.6	.431	.950
7) Other professionals (therapists, physicians) indicate they value nurses pursuing their education, extending their knowledge, and increasing their competence.	176.8	.396	.950
8) Our nurse manager makes it possible for nurses on the unit to attend continuing education, outside courses and/or degree completion programs.	176.5	.537	.950
9) In this organization, there are few rewards such as salary increases or promotion for pursuing one's education*.	177.4	.229	.951
10) This organization provides financial assistance and/or paid time off for nurses to attend educational programs.	176.6	.394	.950
11) Nurses here fear 'getting into trouble' or 'taking big risks' if they make independent, autonomous decisions*.	177.2	.483	.950
12) Autonomous nursing practice is facilitated because nurses 'feel' or know that nurse managers will support them.	177.1	.650	.949
13) Staff nurses must obtain orders or consent from an authority source before making independent or interdependent decisions*.	177.6	.300	.951
14) On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decisions in those spheres where nursing overlaps with other disciplines.	176.8	.469	.950
15) Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions.	176.7	.456	.950

16) This organization has many rules and regulations that prevent nurses from making independent or interdependent decisions*.	177.1	.430	.950
17) In this hospital, nurses have to do things that, in our professional judgment, may not be in the best interests of the patient*.	177.0	.330	.951
18) Nurses are held accountable in a positive, constructive, learning way for the outcomes of autonomous clinical nursing practice.	176.9	.557	.950
19) There is a general understanding among nurses on my unit that nursing administration wants us to function autonomously.	177.2	.510	.950
20) We have a council or committee structure through which nurses on our unit and in this hospital control nursing practice.	176.8	.500	.950
21) Staff nurses have input and make decisions with respect to *practice* issues and policies such as selection of equipment, how frequently to change IV line dressings, etc.	176.9	.455	.950
22) Physicians, administrators, nurses and other professionals (ex. physical therapists) recognize that nursing in this hospital controls its own practice.	177.1	.464	.950
23) Shared decision-making is more talk than action here; clinical (staff) nurses don't take part in decision-making*.	177.1	.483	.950
24) Representatives from other departments and disciplines such as transportation, pharmacy, respiratory therapy, participate in our shared decision-making activities on a regular basis.	177.2	.314	.951
25) Nurses in this organization have input and make decisions related to *personnel* issues and policies that directly affect them such as floating, schedules, care delivery system.	177.2	.432	.950
26) Nurses on my unit can describe decisions made and outcomes achieved as a result of our shared decision-making process.	177.0	.607	.950
27) Nursing practice, policies, issues and standards are determined by nursing management, administration or people outside of nursing. Staff nurses do not have control*.	177.3	.485	.950
28) The nurses on my unit judge that, most of the time, we are adequately staffed to give *quality patient care*.	177.2	.559	.950
29) We don't have enough competent and experienced nurses who 'know' the unit, patients and physicians to provide *safe* care*.	176.8	.411	.950
30) We modify our patient care delivery system (Ex. team, primary) on the basis of the number and experience of RNs available.	177.2	.217	.951
31) We work as a team on our unit. We need one another and need to work together if patients are to receive high quality care.	176.4	.448	.950
32) Our group cohesiveness enables us to give quality care with our current level of staffing.	176.7	.502	.950
33) Our unit is not a sufficient number of budgeted RN positions for the acuity of our patients. This makes it difficult to give quality patient care even when all budgeted positions are filled*.	177.2	.493	.950
34) Nurses on my unit demonstrate a proficiency level of competence.	176.6	.487	.950

35) Nurses' competent performances are recognized and rewarded both on my unit and in this organization.	177.0	.598	.949
36) Continuing education toward a nursing degree is recognized as a way in which nurses can increase their nursing competence.	176.7	.531	.950
37) National certification is recognized as evidence of proficient clinical competence.	176.6	.545	.950
38) Our nurse manager represents the positions and interests of the staff and of our unit to other departments and to administration. He/she "watches our back".	176.9	.693	.949
39) If we need resources such as equipment or supplies, our nurse manager sees to it that we get these.	176.8	.603	.949
40) Our manager is diplomatic, fair and honest in resolving conflicts between nurses, physicians or other departments.	176.9	.624	.949
41) Our nurse manager supports and encourages interdisciplinary—physicians, nurses, and other disciplines—planning and action.	176.7	.621	.949
42) The nurse manager on our unit sees to it that we have adequate numbers of competent staff to get the job done.	177.0	.684	.949
43) Our nurse manager cites specific examples, both positive and negative, when he/she provides us feedback.	176.9	.629	.949
44) The nurse manager of our unit promotes staff cohesion and is a positive force in getting us to work together.	176.9	.672	.949
45) Our manager is visible, available, approachable and 'safe'.	176.8	.650	.949
46) Our manager teaches us the values of the organization regarding patient care and "puts the values into action".	176.8	.693	.949
47) Our manager fosters sound decision-making by asking for 'best practice' evidence for the decisions we are making	176.8	.670	.949
48) This hospital is willing to try new things.	176.7	.421	.950
49) Concern for the patient is paramount on my unit and in this hospital.	176.5	.528	.950
50) Problems are solved by swift action; people are not afraid to take risks.	177.1	.537	.950
51) People on my unit are enthusiastic about their work	177.0	.591	.949
52) High performance and productivity are expected of everyone.	176.5	.409	.950
53) We work together as a team, both within nursing and with medicine and other disciplines.	176.7	.589	.950
54) Cost (money) is important, but quality patient care comes first in this organization.	177.0	.543	.950
55) The contributions of all members of the staff (RNs, nurse assistants, techs) are important and are valued.	176.7	.571	.950
56) Our administration anticipates organizational changes that need to be made because of changes in the health care system, and sees to it that we are out in front.	176.9	.547	.950

57) This is a value driven organization. Values are known, understood, shared, and frequently talked about.	176.8	.607	.950
58) We make a conscious effort to transmit our cultural values to incoming nurses, physicians, techs and assistants.	176.8	.565	.950
59) Circle a number that indicates the usual quality of care provided to patients on your unit.	171.5	.535	.950

Table L 4.2

Reliability Item Analysis of Essentials of Magnetism II for the Pre-Implementation Independent Sample

Items Overall Cronbach's alpha 0.949	Scale Mean if Item Deleted	Corrected Item-Total Correlation	Cronbach Alpha if Item Deleted
1) Nurse-physician relationships on my unit are that of a 'student-teacher' with physicians willing to explain and teach the nurses.	177.4	.418	.948
2) Nurse-physician relationships consist of willing cooperation based on *mutual* power, trust, and respect.	177.2	.525	.948
3) Relationships between nurses and physicians are frustrating, hostile and characterized by 'power plays,' antagonism or resentment*.	177.5	.422	.948
4) Relationships with MDs are that of 'student-teacher' with RNs influencing MDs in their prescribing care for patients.	177.6	.309	.949
5) Our nurse-physician relationships are rather formal and characterized mainly by the nurse responding to the physician's questions*.	177.8	.129	.950
6) Physicians treat nurses on this unit as *equals.* MDs need RNs' assessments/observations and RNs need MDs medical knowledge if together we are going to help the patient.	177.3	.566	.948
7) Other professionals (therapists, physicians) indicate they value nurses pursuing their education, extending their knowledge, and increasing their competence.	177.3	.428	.948
8) Our nurse manager makes it possible for nurses on the unit to attend continuing education, outside courses and/or degree completion programs.	177.1	.574	.948
9) In this organization, there are few rewards such as salary increases or promotion for pursuing one's education*.	178.0	.174	.950
10) This organization provides financial assistance and/or paid time off for nurses to attend educational programs.	177.3	.355	.949
11) Nurses here fear 'getting into trouble' or 'taking big risks' if they make independent, autonomous decisions*.	177.7	.411	.949
12) Autonomous nursing practice is facilitated because nurses 'feel' or know that nurse managers will support them.	177.7	.607	.948
13) Staff nurses must obtain orders or consent from an authority source before making independent or interdependent decisions*.	178.2	.139	.950
14) On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decisions in those spheres where nursing overlaps with other disciplines.	177.3	.371	.949
15) Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions.	177.2	.526	.948

16)	This organization has many rules and regulations that prevent nurses from making independent or interdependent decisions*.	177.8	.387	.949
17)	In this hospital, nurses have to do things that, in our professional judgment, may not be in the best interests of the patient*.	177.7	.306	.949
18)	Nurses are held accountable in a positive, constructive, learning way for the outcomes of autonomous clinical nursing practice.	177.5	.594	.948
19)	There is a general understanding among nurses on my unit that nursing administration wants us to function autonomously.	177.7	.366	.949
20)	We have a council or committee structure through which nurses on our unit and in this hospital control nursing practice.	177.3	.465	.948
21)	Staff nurses have input and make decisions with respect to *practice* issues and policies such as selection of equipment, how frequently to change IV line dressings, etc.	177.5	.401	.949
22)	Physicians, administrators, nurses and other professionals (ex. physical therapists) recognize that nursing in this hospital controls its own practice.	177.7	.485	.948
23)	Shared decision-making is more talk than action here; clinical (staff) nurses don't take part in decision-making*.	177.7	.461	.948
24)	Representatives from other departments and disciplines such as transportation, pharmacy, respiratory therapy, participate in our shared decision-making activities on a regular basis.	177.7	.395	.949
25)	Nurses in this organization have input and make decisions related to *personnel* issues and policies that directly affect them such as floating, schedules, care delivery system.	177.7	.542	.948
26)	Nurses on my unit can describe decisions made and outcomes achieved as a result of our shared decision-making process.	177.5	.616	.948
27)	Nursing practice, policies, issues and standards are determined by nursing management, administration or people outside of nursing. Staff nurses do not have control*.	177.9	.364	.949
28)	The nurses on my unit judge that, most of the time, we are adequately staffed to give *quality patient care*.	177.8	.414	.949
29)	We don't have enough competent and experienced nurses who 'know' the unit, patients and physicians to provide *safe* care*.	177.5	.439	.948
30)	We modify our patient care delivery system (Ex. team, primary) on the basis of the number and experience of RNs available.	177.8	.115	.950
31)	We work as a team on our unit. We need one another and need to work together if patients are to receive high quality care.	177.0	.462	.948
32)	Our group cohesiveness enables us to give quality care with our current level of staffing.	177.3	.593	.948
33)	Our unit is not a sufficient number of budgeted RN positions for the acuity of our patients. This makes if difficult to give quality patient care even when all budgeted positions are filled*.	177.9	.538	.948
34)	Nurses on my unit demonstrate a proficiency level of competence.	177.2	.465	.948
35)	Nurses' competent performances are recognized and rewarded both on my unit and in this organization.	177.7	.494	.948

36)	Continuing education toward a nursing degree is recognized as a way in which nurses can increase their nursing competence.	177.3	.495	.948
37)	National certification is recognized as evidence of proficient clinical competence.	177.2	.470	.948
38)	Our nurse manager represents the positions and interests of the staff and of our unit to other departments and to administration. He/she "watches our back".	177.6	.644	.947
39)	If we need resources such as equipment or supplies, our nurse manager sees to it that we get these.	177.3	.613	.948
40)	Our manager is diplomatic, fair and honest in resolving conflicts between nurses, physicians or other departments.	177.5	.581	.948
41)	Our nurse manager supports and encourages interdisciplinary—physicians, nurses, and other disciplines—planning and action.	177.2	.672	.947
42)	The nurse manager on our unit sees to it that we have adequate numbers of competent staff to get the job done.	177.4	.710	.947
43)	Our nurse manager cites specific examples, both positive and negative, when he/she provides us feedback.	177.4	.679	.947
44)	The nurse manager of our unit promotes staff cohesion and is a positive force in getting us to work together.	177.4	.663	.947
45)	Our manager is visible, available, approachable and 'safe'.	177.4	.618	.947
46)	Our manager teaches us the values of the organization regarding patient care and "puts the values into action".	177.4	.703	.947
47)	Our manager fosters sound decision-making by asking for 'best practice' evidence for the decisions we are making	177.4	.641	.948
48)	This hospital is willing to try new things.	177.4	.477	.948
49)	Concern for the patient is paramount on my unit and in this hospital.	177.2	.526	.948
50)	Problems are solved by swift action; people are not afraid to take risks.	177.8	.449	.948
51)	People on my unit are enthusiastic about their work	177.6	.666	.947
52)	High performance and productivity are expected of everyone.	177.1	.445	.948
53)	We work together as a team, both within nursing and with medicine and other disciplines.	177.3	.717	.947
54)	Cost (money) is important, but quality patient care comes first in this organization.	177.6	.496	.948
55)	The contributions of all members of the staff (RNs, nurse assistants, techs) are important and are valued.	177.3	.602	.948
56)	Our administration anticipates organizational changes that need to be made because of changes in the health care system, and sees to it that we are out in front.	177.5	.453	.948
57)	This is a value driven organization. Values are known, understood, shared, and frequently talked about.	177.4	.596	.948

58) We make a conscious effort to transmit our cultural values to incoming nurses, physicians, techs and assistants.	177.4	.536	.948
59) Circle a number that indicates the usual quality of care provided to patients on your unit.	172.1	.489	.949

Table L 4.3

Reliability Item Analysis of Essentials of Magnetism II for the Post-Implementation Independent Sample

Items Overall Cronbach's alpha 0.953	Scale Mean if Item Deleted	Corrected Item-Total Correlation	Cronbach Alpha if Item Deleted
1) Nurse-physician relationships on my unit are that of a 'student-teacher' with physicians willing to explain and teach the nurses.	181.3	.253	.954
2) Nurse-physician relationships consist of willing cooperation based on *mutual* power, trust, and respect.	181.2	.354	.953
3) Relationships between nurses and physicians are frustrating, hostile and characterized by 'power plays,' antagonism or resentment*.	181.2	.273	.953
4) Relationships with MDs are that of 'student-teacher' with RNs influencing MDs in their prescribing care for patients.	181.5	.176	.954
5) Our nurse-physician relationships are rather formal and characterized mainly by the nurse responding to the physician's questions*.	181.6	.104	.954
6) Physicians treat nurses on this unit as *equals.* MDs need RNs' assessments/observations and RNs need MDs medical knowledge if together we are going to help the patient.	181.1	.418	.953
7) Other professionals (therapists, physicians) indicate they value nurses pursuing their education, extending their knowledge, and increasing their competence.	181.2	.402	.953
8) Our nurse manager makes it possible for nurses on the unit to attend continuing education, outside courses and/or degree completion programs.	181.0	.602	.952
9) In this organization, there are few rewards such as salary increases or promotion for pursuing one's education*.	181.8	.241	.954
10) This organization provides financial assistance and/or paid time off for nurses to attend educational programs.	181.0	.371	.953
11) Nurses here fear 'getting into trouble' or 'taking big risks' if they make independent, autonomous decisions*.	181.5	.548	.952
12) Autonomous nursing practice is facilitated because nurses 'feel' or know that nurse managers will support them.	181.5	.644	.952
13) Staff nurses must obtain orders or consent from an authority source before making independent or interdependent decisions*.	181.9	.173	.954
14) On this unit, nurses make independent decisions within the nursing sphere of practice and interdependent decisions in those spheres where nursing overlaps with other disciplines.	181.2	.491	.952
15) Our evidence-based practice activities provide us with the knowledge base needed to make sound clinical decisions.	181.1	.511	.952
16) This organization has many rules and regulations that prevent nurses from making independent or interdependent decisions*.	181.6	.502	.952

17)	In this hospital, nurses have to do things that, in our professional judgment, may not be in the best interests of the patient*.	181.4	.392	.953
18)	Nurses are held accountable in a positive, constructive, learning way for the outcomes of autonomous clinical nursing practice.	181.3	.571	.952
19)	There is a general understanding among nurses on my unit that nursing administration wants us to function autonomously.	181.5	.585	.952
20)	We have a council or committee structure through which nurses on our unit and in this hospital control nursing practice.	181.1	.526	.952
21)	Staff nurses have input and make decisions with respect to *practice* issues and policies such as selection of equipment, how frequently to change IV line dressings, etc.	181.3	.532	.952
22)	Physicians, administrators, nurses and other professionals (ex. physical therapists) recognize that nursing in this hospital controls its own practice.	181.5	.491	.952
23)	Shared decision-making is more talk than action here; clinical (staff) nurses don't take part in decision-making*.	181.5	.598	.952
24)	Representatives from other departments and disciplines such as transportation, pharmacy, respiratory therapy, participate in our shared decision-making activities on a regular basis.	181.5	.377	.953
25)	Nurses in this organization have input and make decisions related to *personnel* issues and policies that directly affect them such as floating, schedules, care delivery system.	181.5	.561	.952
26)	Nurses on my unit can describe decisions made and outcomes achieved as a result of our shared decision-making process.	181.3	.624	.952
27)	Nursing practice, policies, issues and standards are determined by nursing management, administration or people outside of nursing. Staff nurses do not have control*.	181.6	.414	.953
28)	The nurses on my unit judge that, most of the time, we are adequately staffed to give *quality patient care*.	181.6	.487	.952
29)	We don't have enough competent and experienced nurses who 'know' the unit, patients and physicians to provide *safe* care*.	181.2	.449	.953
30)	We modify our patient care delivery system (Ex. team, primary) on the basis of the number and experience of RNs available.	181.6	.217	.954
31)	We work as a team on our unit. We need one another and need to work together if patients are to receive high quality care.	180.9	.478	.952
32)	Our group cohesiveness enables us to give quality care with our current level of staffing.	181.1	.500	.952
33)	Our unit is not a sufficient number of budgeted RN positions for the acuity of our patients. This makes if difficult to give quality patient care even when all budgeted positions are filled*.	181.6	.470	.953
34)	Nurses on my unit demonstrate a proficiency level of competence.	180.9	.509	.952
35)	Nurses' competent performances are recognized and rewarded both on my unit and in this organization.	181.3	.656	.952
36)	Continuing education toward a nursing degree is recognized as a way in which nurses can increase their nursing competence.	181.1	.580	.952

37)	National certification is recognized as evidence of proficient clinical competence.	181.0	.536	.952
38)	Our nurse manager represents the positions and interests of the staff and of our unit to other departments and to administration. He/she "watches our back".	181.3	.684	.951
39)	If we need resources such as equipment or supplies, our nurse manager sees to it that we get these.	181.2	.655	.952
40)	Our manager is diplomatic, fair and honest in resolving conflicts between nurses, physicians or other departments.	181.3	.692	.951
41)	Our nurse manager supports and encourages interdisciplinary—physicians, nurses, and other disciplines—planning and action.	181.1	.705	.951
42)	The nurse manager on our unit sees to it that we have adequate numbers of competent staff to get the job done.	181.3	.667	.952
43)	Our nurse manager cites specific examples, both positive and negative, when he/she provides us feedback.	181.3	.672	.952
44)	The nurse manager of our unit promotes staff cohesion and is a positive force in getting us to work together.	181.3	.728	.951
45)	Our manager is visible, available, approachable and 'safe'.	181.2	.699	.951
46)	Our manager teaches us the values of the organization regarding patient care and "puts the values into action".	181.2	.699	.952
47)	Our manager fosters sound decision-making by asking for 'best practice' evidence for the decisions we are making	181.2	.676	.952
48)	This hospital is willing to try new things.	181.1	.490	.952
49)	Concern for the patient is paramount on my unit and in this hospital.	181.1	.550	.952
50)	Problems are solved by swift action; people are not afraid to take risks.	181.5	.568	.952
51)	People on my unit are enthusiastic about their work	181.4	.609	.952
52)	High performance and productivity are expected of everyone.	181.1	.471	.952
53)	We work together as a team, both within nursing and with medicine and other disciplines.	181.1	.598	.952
54)	Cost (money) is important, but quality patient care comes first in this organization.	181.4	.512	.952
55)	The contributions of all members of the staff (RNs, nurse assistants, techs) are important and are valued.	181.2	.722	.951
56)	Our administration anticipates organizational changes that need to be made because of changes in the health care system, and sees to it that we are out in front.	181.2	.504	.952
57)	This is a value driven organization. Values are known, understood, shared, and frequently talked about.	181.2	.594	.952
58)	We make a conscious effort to transmit our cultural values to in-coming nurses, physicians, techs and assistants.	181.2	.476	.952

59) Circle a number that indicates the **<u>usual quality of care provided to patients</u>** on your unit.	175.9	.423	.954

APPENDIX M: ANALYSIS OF POTENTIALLY CONFOUNDING OPERATIONAL DATA: DCHPPD AND TURNOVER

Table M 4.1

Mean Direct Care Hours Per Day (DCHPPD) Ratio by Month

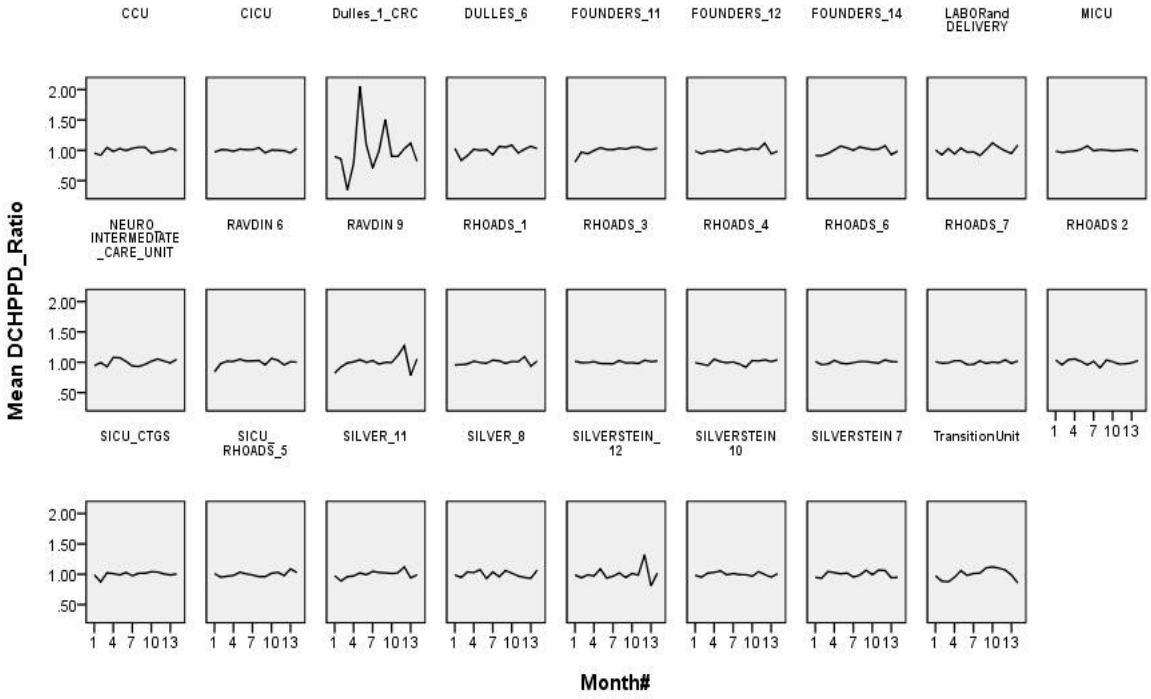


Table M 4.2

Mean Turnover by Month

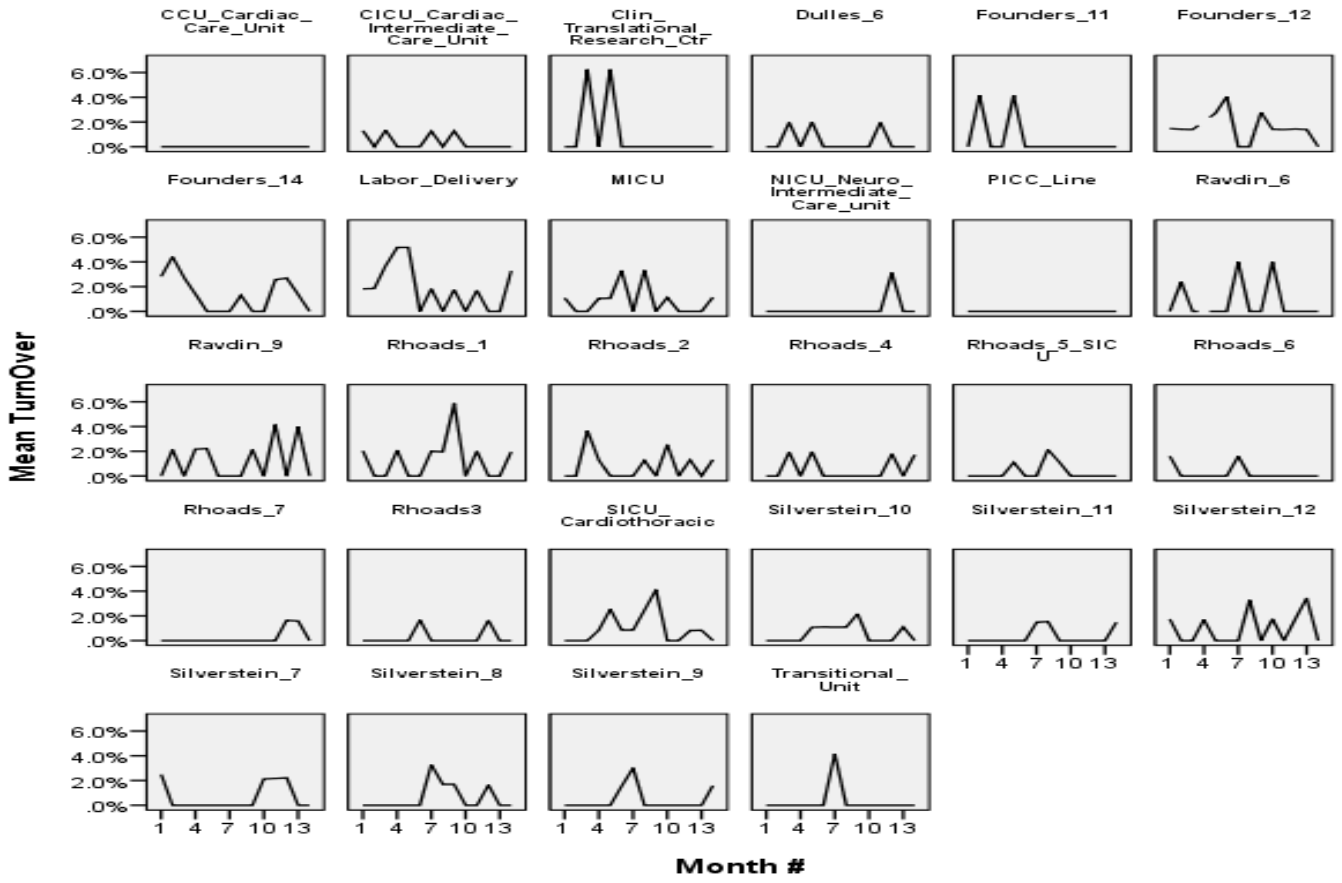


Table M 4.3

Correlations of Dependent Subscale Variables at Month 6 (Pre-Implementation) and Month 14 (Post-Implementation) with Operational Control Variables

I-HIT Paired Sample Pearson's Correlation: Month 6 for DCHPPD and Turnover

Correlations

		HITGA Phase 1	HITWF Phase 1	HITSCT Phase 1	HITSIT Phase 1	HIT Depersonalize Phase 1
DCHPPD_Ratio.6	Pearson Correlation	.043	.018	-.020	-.012	-.002
	Sig. (2-tailed)	.384	.725	.687	.808	.961
	N	408	406	411	403	401
TurnOver.6: TurnOver	Pearson Correlation	-.094	-.088	-.124*	-.158**	-.038
	Sig. (2-tailed)	.058	.074	.011	.001	.448
	N	411	411	416	408	405

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

I-HIT Paired Sample Spearman Correlations: Month 6 for DCHPPD and Turnover

Correlations

			HITGA Phase 1	HITWF Phase 1	HITSCT Phase 1	HITSIT Phase 1	HIT Depersonalize Phase 1
Spearman's rho	DCHPPD_Ratio.6	Correlation Coefficient	.022	.011	-.015	.006	-.013
		Sig. (2-tailed)	.665	.822	.762	.899	.800
		N	408	406	411	403	401
	TurnOver.6: TurnOver	Correlation Coefficient	-.149**	-.122*	-.140**	-.105*	-.060
		Sig. (2-tailed)	.002	.014	.004	.033	.227
		N	411	411	416	408	405

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

I-HIT Paired Sample Pearson's Correlation: Month 14 for DCHPPD and Turnover

Correlations

		HITGA Phase 2	HITWF Phase 2	HITSCT Phase 2	HITSIT Phase 2	HIT Depersonalize Phase 2
TurnOver.14: TurnOver	Pearson Correlation	.036	-.010	-.013	.009	-.007
	Sig. (2-tailed)	.452	.840	.788	.854	.890
	N	435	435	434	431	428
DCHPPD_Ratio.14	Pearson Correlation	-.161**	-.145**	-.071	-.106*	-.111*
	Sig. (2-tailed)	.001	.003	.143	.029	.022
	N	430	430	429	426	425

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

I-HIT Paired Sample Spearman Correlation: Month 14 for DCHPPD and Turnover

Correlations

			HITGA Phase 2	HITWF Phase 2	HITSCT Phase 2	HITSIT Phase 2	HIT Depersonalize Phase 2
Spearman's rho	TurnOver.14: TurnOver	Correlation Coefficient	.005	-.043	-.051	-.010	-.041
		Sig. (2-tailed)	.920	.375	.288	.831	.400
		N	435	435	434	431	428
	DCHPPD_Ratio.14	Correlation Coefficient	-.082	-.094	-.050	-.032	-.049
		Sig. (2-tailed)	.090	.051	.300	.506	.314
		N	430	430	429	426	425

I-HIT Independent Sample Pearson's Correlation: DCHPPD and Turnover

Correlations

		HITGA_Subscale	HITWF_Subscale	HITSIT_Subscale	HITSCT_Subscale	R_HTWFDepersonalize_CD
Turnover	Pearson Correlation	-.070	-.054	-.077	-.019	-.008
	Sig. (2-tailed)	.106	.209	.077	.654	.854
	N	538	539	525	535	526
DCHPPD_Ratio	Pearson Correlation	-.011	-.037	-.020	-.009	-.047
	Sig. (2-tailed)	.798	.391	.654	.834	.287
	N	537	538	525	534	525

I-HIT Independent Sample Spearman Correlation: DCHPPD and Turnover

Correlations

			HITGA_Subscale	HITWF_Subscale	HITSIT_Subscale	HITSCT_Subscale	R_HTWFDepersonalize_CD
Spearman's rho	Turnover	Correlation Coefficient	-.111*	-.094*	-.073	-.059	-.017
		Sig. (2-tailed)	.010	.030	.094	.171	.695
		N	538	539	525	535	526
	DCHPPD_Ratio	Correlation Coefficient	-.070	-.064	-.050	-.036	.023
		Sig. (2-tailed)	.103	.140	.250	.411	.592
		N	537	538	525	534	525

*. Correlation is significant at the 0.05 level (2-tailed).

EOM II Paired Sample Pearson's Correlation: Month 6 for DCHPPD and Turnover

Correlations

		Support for Education P1	RNMd Relationships P1	Working with Clinically Competent Peers P1	Clinical Autonomy P1	Control over Nursing Practice P1	Perception of Adequate Staffing P1	Patient-Centered Values P1	Nurse Manager Support Index P1	Professional Practice Satisfction P1	Nurse Assessed QoC P1
DCHPPD_Ratio.6	Pearson Correlation	.027	.201**	.087	.072	.094	.129**	.097*	.014	.125**	.073
	Sig. (2-tailed)	.576	.000	.072	.138	.053	.007	.044	.769	.010	.132
	N	430	430	427	429	427	427	426	427	427	427
TurnOver.6: TurnOver	Pearson Correlation	-.149**	.093	-.051	-.080	-.065	.018	-.020	-.119*	-.059	.004
	Sig. (2-tailed)	.002	.052	.286	.096	.178	.713	.684	.014	.224	.941
	N	435	435	432	434	432	432	431	432	432	432

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

EOM II Paired Sample Spearman Correlations: Month 6 for DCHPPD and Turnover

Correlations

			Support for Education P1	RNMd Relationships P1	Working with Clinically Competent Peers P1	Clinical Autonomy P1	Control over Nursing Practice P1	Perception of Adequate Staffing P1	Patient-Centered Values P1	Nurse Manager Support Index P1	Professional Practice Satisfction P1	Nurse Assessed QoC P1
Spearman's rho	DCHPPD_Ratio.6	Correlation Coefficient	.001	.134**	.048	.013	.067	.054	.046	-.039	.057	.034
		Sig. (2-tailed)	.978	.005	.321	.782	.166	.267	.345	.418	.240	.480
		N	430	430	427	429	427	427	426	427	427	427
	TurnOver.6: TurnOver	Correlation Coefficient	-.183**	.039	-.083	-.049	-.059	.059	-.033	-.175**	-.074	.015
		Sig. (2-tailed)	.000	.412	.084	.313	.219	.219	.494	.000	.125	.751
		N	435	435	432	434	432	432	431	432	432	432

**. Correlation is significant at the 0.01 level (2-tailed).

EOM II Paired Sample Pearson's Correlation: Month 14 for DCHPPD and Turnover

Correlations

		Support for Education P2	RNMd Relationships P2	Working with Clinically Competent Peers P2	Clinical Autonomy P2	Control over Nursing Practice P2	Perception of Adequate Staffing P2	Patient-Centered Values P2	Nurse Manager Support Index P2	Professional Practice Satisfction P2	Nurse Assessed QoC P2
TurnOver.14: TurnOver	Pearson Correlation	.009	.029	-.058	-.052	.009	-.202**	-.044	-.050	-.038	-.128**
	Sig. (2-tailed)	.857	.541	.228	.283	.845	.000	.356	.299	.431	.008
	N	435	435	433	435	434	433	433	433	433	433
DCHPPD_Ratio.14	Pearson Correlation	-.056	-.066	-.056	-.101*	-.063	.064	.017	-.038	-.070	.018
	Sig. (2-tailed)	.244	.172	.244	.037	.192	.183	.721	.438	.146	.705
	N	430	430	428	430	429	428	428	428	428	428

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

EOM II Paired Sample Spearman Correlations: Month 14 for DCHPPD and Turnover

Correlations

			Support for Education P2	RNMd Relationships P2	Working with Clinically Competent Peers P2	Clinical Autonomy P2	Control over Nursing Practice P2	Perception of Adequate Staffing P2	Patient-Centered Values P2	Nurse Manager Support Index P2	Professional Practice Satisfction P2	Nurse Assessed QoC P2
Spearman's rho	TurnOver.14: TurnOver	Correlation Coefficient	.006	.093	-.066	-.039	-.003	-.215**	-.043	-.072	-.039	-.124**
		Sig. (2-tailed)	.909	.053	.168	.418	.958	.000	.378	.134	.414	.010
		N	435	435	433	435	434	433	433	433	433	433
	DCHPPD_Ratio.14	Correlation Coefficient	.025	-.047	.012	-.016	.017	.101*	.059	.118*	.030	.001
		Sig. (2-tailed)	.610	.326	.809	.740	.725	.037	.223	.014	.538	.981
		N	430	430	428	430	429	428	428	428	428	428

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

EOMII Independent Sample Pearson's Correlation: DCHPPD and Turnover

Correlations

		SupEd	RnMd	WkgCC	Auto	CNP	Staff	Values	NMSupIdx	PROFPSAT	EOM_NurseAssessQual_Sum
Turnover	Pearson Correlation	-.006	-.018	-.096*	-.090*	-.020	-.109*	-.077	-.135**	-.087*	-.089*
	Sig. (2-tailed)	.894	.672	.025	.035	.642	.011	.072	.002	.043	.038
	N	549	550	546	548	545	546	546	547	545	546
DCHPPD_Ratio	Pearson Correlation	.004	-.003	-.036	-.031	.029	-.002	.006	-.102*	-.020	.061
	Sig. (2-tailed)	.930	.938	.399	.466	.498	.955	.893	.017	.639	.154
	N	548	549	545	547	544	545	545	546	544	545

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

EOM II Independent Sample Spearman Correlation: DCHPPD and Turnover

Correlations

			SupEd	RnMd	WkgCC	Auto	CNP	Staff	Values	NMSupIdx	PROFPSAT	EOM_NurseAssessQual_Sum
Spearman's rho	Turnover	Correlation Coefficient	-.007	.006	-.116**	-.069	.016	-.117**	-.057	-.136**	-.073	-.094*
		Sig. (2-tailed)	.870	.887	.007	.106	.708	.006	.185	.001	.087	.027
		N	549	550	546	548	545	546	546	547	545	546
	DCHPPD_Ratio	Correlation Coefficient	.029	.012	-.025	-.010	.059	.023	.054	-.063	.015	.024
		Sig. (2-tailed)	.494	.777	.554	.818	.172	.588	.205	.143	.722	.574
		N	548	549	545	547	544	545	545	546	544	545

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX N: REGRESSION MODELS--BACKWARD ELIMINATION OF INDEPENDENT VARIABLES

Table N 4.1

Sequential Backward Elimination of Independent Variables from Repeated Measure GLM Models

		Main Effect Sig.	Interaction Sig.
1.	***I-HIT: General Advantages of HIT***		
1	Clinical Ladder	.407	.797
2	Shift	.108	.115
2.	***I-HIT: Workflow Implications of HIT***		
1	Years HUP Tenure_Continuous	.258	.699
2	Hours per pay period (80 hours)	.300	.245
3.	***I-HIT: Information Tools to Support Communication Tasks***		
	No Independent Variables were eliminated. The full model was the final model.		
4.	***I-HIT: Information Tools to Support Information Tasks***		
1	Shift	.615	.315
2	Hours per pay period (80 hours)	.445	.220
3	Ethnicity	.276	.118
5.	***I-HIT: HIT Depersonalizes Care***		
1	Clinical Ladder	.791	.143
2	Shift	.279	.667
3	Age	.769	.112
6.	***EOM II: RNMD Relationships***		
	No Independent Variables were eliminated. The full model was the final model. All main effects were significant =< 0.1. However, there were no significant interaction variables.		
7.	***EOM II: Support for Education***		
1	Age	.726	.719
2	Clinical Ladder	.805	.289

3	Total Years Experience_Coded	.484	.249
4	Education	.103	.793
8.	***EOM II: Clinical Autonomy***		
1	Clinical Ladder	.724	.233
2	Race	.250	.182
9.	***EOM II: Control Over Nursing Practice***		
1	Years HUP Tenure_Continuous	.641	.990
2	Age	.638	.123
3	Race	.608	.243
4	Sex	.470	.450
10.	***EOM II: Perception that Staffing is Adequate***		
1	Age	.956	.305
2	Prior electronic clinical documentation system experience	.558	.303
11.	***EOM II: Working with Clinically Competent Peers***		
1	Years HUP Tenure_Continuous	.872	.834
2	Sex	.951	.159
3	Prior electronic clinical documentation system experience	.964	.122
12.	***EOM II: Nurse Manager Support Index***		
1	Age	.554	.294
13.	***EOM II: Patient-Centered Cultural Values***		
1	Race	.205	.529
14.	***EOM II: Professional Practice Satisfaction***		
1	Total Years Experience_Continuous	.127	.291
15.	***EOM II: Nurse-Assessed Quality of Care on Unit***		
1	Education Outside of USA	.761	.500
2	Sex	.666	.135
3	Race	.530	.282
4	Prior electronic clinical documentation system experience	.410	.446

Table N 4.2

Sequential Backward Elimination of Independent Variables from Univariate GLM Models

		Main Effect Sig.	Interaction Sig
1.	***I-HIT: General Advantages of HIT***		
1	Age	.940	.121
2	Sex	.839	.261
3	Years HUP Tenure_Continuous*Group		.692
4	Ethnicity	.226	.110
5	Education	.204	
6	Years HUP Tenure_Continuous	.288	
7	Clinical Ladder*Group		.146
2.	***I-HIT: Workflow Implications of HIT***		
1	Shift	.584	.169
2	Years HUP Tenure_Continuous	.274	.673
3	Sex	.373	.184
4	Clinical Ladder*Group		.480
5	Education	.169	
3.	***I-HIT: Information Tools to Support Communication Tasks***		
1	Years HUP Tenure_Continuous	.992	.215
2	Sex	.138	.245
4.	***I-HIT: Information Tools to Support Information Tasks***		
1	Age	.948	.161
2	Years HUP Tenure_Continuous	.780	.214
3	Sex*Group		.112
4	Sex	.104	
5.	***I-HIT: HIT Depersonalizes Care***		
1	Prior electronic clinical documentation system experience	.282	.340
2	Years HUP Tenure_Continuous	.141	
3	Race	.119	
6.	***EOM II: Support for Education***		
1	Clinical Ladder	.862	.202
2	Education	.387	
3	Prior electronic clinical documentation system experience	.362	

4	Age	.181	
5	Education Outside of USA	.343	.110
6	Hours per pay period (80 hours)	.150	
7	Race	.115	

7. ***EOM II: RNMD Relationships***

1	Education Outside of USA	.909	.178
2	Race	.869	.169
3	Years HUP Tenure_Continuous	.619	.717
4	Hours per pay period (80 hours)	.609	.259
5	Clinical Ladder	.270	

8. ***EOM II: Clinical Autonomy***

1	Hours per pay period (80 hours)	.453	.470
2	Years HUP Tenure_Continuous*Group		.951
3	Race	.554	
4	Sex	.774	.143
5	Age	.131	.542

9. ***EOM II: Control Over Nursing Practice***

1	Ethnicity		.715
2	Hours per pay period (80 hours)	.153	.624
3	Ethnicity* Group		.450
4	Clinical Unit Type* Group		.212
5	Age	.154	
6	Ethnicity	.134	
7	Years HUP Tenure_Continuous	.145	

10. ***EOM II: Perception that Staffing is Adequate***

1	Years HUP Tenure_Coded	.344	

11. ***EOM II: Working with Clinically Competent Peers***

1	Age	.142	.535
2	Years HUP Tenure_Continuous	.149	.668
3	Clinical Unit Type	.132	

12. ***EOM II: Nurse Manager Support Index***

1	Race	.491	
2	Clinical Ladder	.233	
3	Clinical Unit Type	.140	

13.	***EOM II: Patient-Centered Cultural Values***		
1	Years HUP Tenure_Continuous	.371	.996
2	Race	.220	
14.	***EOM II: Professional Practice Satisfaction***		
1	Race	.962	.184
2	Hours per pay period (80 hours)	.547	.401
3	Years HUP Tenure_Continuous	.127	.516
4	Ethnicity	.237	
15.	***EOM II: Nurse-Assessed Quality of Care on Unit***		
1	Total Years Experience_Coded	.338	

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