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Information technology from novice to expert: implementation implications

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Abstract

Aims—This paper explores how the Novice-to-Expert Nursing Practice framework can illuminate the challenges of and opportunities in implementing information technology (IT), such as clinical decision support systems (CDSS), in nursing practice.

Background—IT implementation in health care is increasing; however, substantial costs and risks remain associated with these projects.

Evaluation—The theoretical framework of Novice-to-Expert Nursing Practice was applied to current design and implementation literature for CDSS.

Key issues—Organizational policies and CDSS design affect implementation and user adoption.

Conclusions—Nursing CDSS can improve the overall quality of care when designed for the appropriate end-user group and based on a knowledge base reflecting nursing expertise.

Implications for nursing management—Nurse administrators can positively influence CDSS function and end-user acceptance by participating in and facilitating staff nurse involvement in IT design, planning and implementation. Specific steps for nurse administrators and managers are included in this paper.

Keywords

clinical; decision support systems; expert systems; Novice-to-Expert nursing practice; nursing administration; nursing informatics

Introduction

Efforts to improve healthcare quality and safety have focused on developing technology designed to improve diagnostic accuracy, provide easier and more rapid access to patient

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information and more complete medical records (Staggers *et al.* 2001). Clinical decision support systems (CDSS) are one prominent example of this type of technology. However, development and implementation of these tools to assist health care providers in their clinical practice has lagged especially in nursing. A significant obstacle has been the identification of nursing information and knowledge. Differential use and manipulation of nursing information by nurses with differing nursing practice levels compound this obstacle. Thus, not all nurses recognize the same nursing data or information as pertinent to their clinical practice and knowledge. The aim of this paper is to explore how Benner *et al.*'s (1992) Novice-to-Expert Nursing Practice framework can illuminate the challenges of and opportunities for planning and implementing a clinical decision support system in nursing practice. Furthermore, we will provide a descriptive overview of clinical decision support systems and discuss the concepts of both nursing knowledge and roles as they pertain to the use of such systems in nursing practice.

Background

Information technology in nursing practice: risk and reward

There has been an increasing trend over the past decade in the use of information technology (IT) in clinical settings; however, there has also been mounting evidence that many of these systems are failing (Despont-Gros *et al.* 2005). Actual costs associated with these system failures are difficult to determine and have rarely been reported. One recommendation to determine costs is to calculate differences in intended and observed effects of implementation processes (Sicotte *et al.* 1998). For example, the process of automation could be equated with the rising costs associated with increased clerical workload. In the nursing process, the elimination of existing processes or duplication could represent decreased costs.

Several reasons can lead to failure or poor adoption of information technology in a health care setting. Information systems failures have been attributed to ineffective ongoing communication, competency of users, intuitiveness of the system design, system acceptance and change management procedures (Lorenzi & Riley 2000, Alexander *et al.* 2007). According to a framework developed by Ammenwerth *et al.* (2006), failure to adopt IT systems in health care settings can be linked to a combination of several factors including attributes of the **individual end users** (e.g. computer anxiety, motivation), **attributes of the technology** (e.g. usability, performance) and **attributes of the clinical tasks and processes** that the IT application introduces or affects (e.g. task complexity). Failure of IT solutions is often also attributed to lack of communication between end users and designers (Bussen & Myers 1997).

Clinical decision support systems

Clinical decision support systems (CDSS) are information systems that model and provide support for human decision-making processes in clinical situations (Sim *et al.* 2001). CDSS use technology to support clinical decision making by interfacing evidenced-based clinical knowledge at the point of care with real-time clinical data at significant clinical decision points (Snyder-Halpern 1999, Spooner 1999, Sim *et al.* 2001). CDSS enable clinician-

computer interactions that move away from traditional data gathering roles to support clinicians as knowledge workers and information users (Ozbolt 1988).

Four classes of CDSS have been described in patient care decision making: systems that (1) use alerts to respond to clinical data, (2) respond to decisions to alter care by critiquing decisions, (3) suggest interventions at the request of a care providers, or (4) conduct retrospective quality assurance reviews. Many systems have been developed for a myriad of clinical issues in acute care settings including diagnosis of chest pain, ventilator management and to improve adherence to recognized HIV treatment guidelines (McKinley *et al.* 2001, Patterson *et al.* 2004, East *et al.* 2005, Garg *et al.* 2005); however these are rarely nursing specific. Nursing-specific decision support systems include nursing diagnosis systems such as the Computer Aided Nursing Diagnosis and Intervention (CANDI) system (Chang *et al.* 1988); care planning systems such as the Urological Nursing Information System (Petrucci *et al.* 1992); symptom management systems such as the Cancer Pain Decision Support system (Im & Chee 2003) and nursing education systems such as the Creighton Online Multiple Modular Expert System (COMMES; Lappe *et al.* 1990). Expert systems have also been proposed for the reduction of nursing care errors through surveillance systems for nursing administrators to detect acute increases in staffing demands (Benner *et al.* 2002). CDSS using an active interaction model, such as generating clinical alerts or reminders with clinician data entry, have been shown to be the most effective in improving clinical practice (Kawamoto *et al.* 2005).

The idea of employing CDSS for nursing is based on the belief that nurses are ‘knowledge workers’ (Snyder-Halpern *et al.* 2001, Marques & Marin 2003). Knowledge workers work within knowledge intensive environments and use information processing and specialized knowledge to evaluate decision-making processes and outcomes (Snyder-Halpern *et al.* 2001). As knowledge workers nurses have four roles: data gatherers, information users, knowledge users and knowledge builders. These roles involve clinical data storage (data gatherer), interpreting clinical data into information (information user), connecting clinical data to domain knowledge (knowledge user) and recognizing clinical data patterns across patients (knowledge builder) (Snyder-Halpern *et al.* 2001). CDSS can support nurses in these various roles. CDSS can assist with data capture and storage for the data user; display and summarize data for the information user; link domain knowledge to clinical data for the knowledge user; and aggregate data to generate clinical patterns across patients for the knowledge builder (Snyder-Halpern *et al.* 2001).

First generation CDSS that assisted in clinical decision making were developed in the 1950s. They were mainly based on methods using decision trees or truth tables; CDSS using statistical probabilities appeared later and were followed by expert systems (Van der Lei & Talmon 1997, Staggers *et al.* 2001). Multiple methods of reasoning have been used in the design of CDSS but all are contingent on a well-developed knowledge base (Sage 1997, Van Bemmel *et al.* 1997, Abbott & Zytkowski 2002).

Fragmented, incomplete or unreliable clinical data sets will hinder the recognition of patterns and associated outcomes. Quality, accuracy and design will ultimately affect the system’s overall performance and its clinical utility. Identifying what information is

pertinent for nursing remains a challenge for the development of clinical decision support systems. Therefore, CDSS that support the data gatherer role can also contribute to the creation of reliable and valid clinical data sets (Snyder-Halpern *et al.* 2001).

Nursing practices: Benner's framework for nursing practice

One of the issues in planning and implementing clinical decision support systems for nurses is the wide variation in knowledge, experience or practice levels. However, the issue of experience level is rarely addressed in most CDSS design with the exception of CDSS that specifically target medical or nursing education.

In her seminal work, Benner (1984) proposed five levels of practice for nursing (novice, advanced beginner, competent, proficient and expert). Later work described four levels of nursing practice (Benner *et al.* 1992) that include: advanced beginner/novice, competent, proficient and expert. Experiential learning was a central component of Benner *et al.*'s adaptation of the Dreyfus Model of Skill Acquisition to clinical nursing practice (Benner *et al.* 1992). These levels of clinical practice mark four major shifts in clinical practice through progression of the different levels (Benner *et al.* 1992) and are useful for understanding how nurses use and generate data and information as their practice evolves over time (Table 1).

Novice/advanced beginners

Novice and advanced beginners (up to 6 months of clinical experience) focus on the immediate needs for action for a clinical situation based on rules, protocols and practice structures such as flow sheets or structured documentation (Benner *et al.* 1992). The focus of their practice is the organization and prioritization of their tasks. Advanced beginners attend to the current clinical situation rather than potential status changes and the potential influence of nursing interventions (Benner *et al.* 1992).

Novice or advanced beginner nurses have also been the target of recent CDSS research initiatives. O'Neill *et al.* (2005) described a theoretical model for novice clinical decision making that was developed as part of their efforts to design a point-of-care CDSS for novice nurses (N-CODES). The model provided by O'Neill *et al.* (2005) corresponds with the narrative descriptions in Benner *et al.* (1992) and Tanner *et al.* (1993).

The advanced beginner's desire for organizing and prioritizing the tasks to be completed can make them a receptive audience for CDSS. However, the decision support provided from CDSS may not be what the advanced beginner needs. CDSS could be beneficial in providing guidance for action for unfamiliar situations for advanced beginners but might not help them in differentiating the clinical situation from textbook examples (Benner *et al.* 1992).

Competent

Competent nurses focus on organization of tasks and care plans. The competent nurse begins to recognize the limitations of protocols and practice structures; however, recognition of and adaptation to changing situations is affected by a preference for pre-set goals and plans and a sense of mastery when a routine is achieved.

The competent nurse may find that CDSS that provide care plans or care trajectories are helpful in setting goals and plans for patient care. However, competent nurses may be more skeptical about the suggestions of a CDSS as a result of an increased recognition that practice structures or directives may not be sufficient. Benner *et al.* (1992) note that competent nurse performance as described by goal setting and standard care plans is what is institutionally rewarded and encouraged as standard practice. An institutional focus on this level of practice could drive CDSS design and create a CDSS that again promotes this level of practice to the detriment of further professional practice growth and patient care.

Proficient

Proficient nurses are better able to see changing relevance in clinical situations (Benner *et al.* 1992). This ability to read the clinical situation quicker allows the proficient nurse to establish situation-specific priorities (Benner *et al.* 1992).

CDSS may not be able to extend the clinical practice of a proficient nurse to an expert practice level. However, the knowledge and experience of proficient and expert nurses can be used in developing CDSS. Proficient nurses should be recruited for both CDSS planning and implementation teams. Bringing advanced beginner nurses and competent nurses to the proficiency practice level rather than expert level may be a realistic goal of the CDSS.

Expert

Expert nursing practice is developed to a greater extent than the proficient nurse's practice. The expert nurse immediately grasps familiar situations and recognizes when he or she does not have a good grasp of a situation (Benner *et al.* 1992). 'Experts are open to the clinical situation in that their grasp is not determined, formed, by expectations, sets and formal knowledge in general, although these aspects are clearly in the background' (Benner *et al.* 1992, p. 25). Tanner *et al.* (1993) note that the expert nurses can only vaguely describe their clinical knowledge.

The difficulty in articulating or formalizing expert practice will also make it difficult to capture this type of clinical knowledge with a CDSS. Additionally, given the nature of expert practice, it is difficult to speculate how a CDSS might enhance an expert nurse's practice. More research is needed to determine what can be translated from expert nursing practice to CDSS to enhance the practice of other nurses. Tanner *et al.* (1993, p. 279) suggest that practice narratives are needed for 'describing the knowledge embedded in the particular, historical, clinical relationship'.

Key issues

The design of CDSS for nurses needs to account for **nursing** data, information and knowledge (Graves & Corcoran 1989). Typically nursing CDSS have been designed for information management purposes rather than knowledge generation. Given the difficulty in identifying pertinent nursing information and describing nursing knowledge, nurses need to be actively involved in the design, planning, implementation and evaluation phases of nursing CDSS. Although this involvement seems obvious, past development and planning of

CDSS for nurses has not always involved nurses (Snyder-Halpern et al. 2001). Recommendations for nursing managers and administrators are included in Table 2.

User participation

User participation in the design and development of information systems such as decision support systems increases the likelihood of successful implementation and utilization of these systems (Barki & Hartwick 1994, Foster & Franz 1999, Demiris 2006). Involvement of end users in the design and implementation of a system is likely to result in increased user satisfaction (Garceau *et al.* 1993, Demiris 2006), and an increase in the perception of usefulness of the application by the end user (Franz & Robey 1986, McKeen *et al.* 1994). On the other hand, lack of communication between end users and designers is often linked to failure of information technology implementations (Bussen & Myers 1997) and misuse of override functions. Thus, it becomes critical for the success of a clinical decision support system that targets or involves nurses as end users to include them in the conceptual phase of the system design.

As stated earlier, end-user involvement in the system design is critical to the overall successful implementation of an information system. In this context, nurses need to be actively involved in the system planning and implementation phases and lead the customization of interfaces based on the different roles they may assume as knowledge workers and end users, namely data gatherers, information users, knowledge users and knowledge builders.

Human computer interaction

Carter noted that several human-computer interaction problems can plague the development of CDSS (1999). These issues include: clinical importance of the CDSS domain; clinician workflow; scope of CDSS (single *vs*. multiple problem use) and organizational readiness (Carter 1999).

For clinicians to adopt a new CDSS, they must feel that it addresses a particular and important concern for clinical practice. For example, a system that addresses prostate cancer treatment, an area which contains substantial uncertainty, could be more useful to clinicians than a system that addresses paediatric bladder training protocols, an area in which standards are well documented and the risk to patients is low.

Likewise, a CDSS must fit within the workflow of the clinician. A system that requires a critical care nurse to leave the bedside for prolonged periods of time is not likely to be adopted. Conversely, systems that are designed to integrate with nurse clinicians established time management practices are more likely to be adopted. For example, clinical reminders for discharge could be delivered ‘just in time’ during the discharge process. Information technology affects work processes, communications and the point of care (Courtney *et al.* 2005). Carter (1999) pointed out that often workflow and CDSS scope problems magnify each other. If a CDSS is designed to provide guidance for a narrow clinical issue, the likelihood of clinicians to interrupt their workflow to use the CDSS diminishes; whereas a system that has a broader scope is more likely to be consulted and integrated into practice.

Lastly, organizational issues are rarely examined when developing a CDSS. Organizational issues include both administrative support (persons and resources) of the project in addition to the identification of 'power users' and 'unit champions' who will help facilitate the CDSS use in practice (Carter 1999).

Systems integration

As noted by Harris *et al.* (2000) nursing languages or data sets that do not capture the clinical data needed by nurses in practice result in redundant systems and additional data collection duties. Similarly, CDSS which are not integrated with clinical records [such as an Electronic Health Record (HER)] can also result in redundant data capture and entry for clinicians (Carter 1999). This additional burden may decrease user acceptance of such systems (Woolery 1990).

Encoding challenges

'There must be acknowledgement that not all nursing knowledge is amenable to computerization. Given nursing's holistic focus, the profession is not able to codify or standardize all of its data, information, and knowledge' (Snyder-Halpern *et al.* 2001, p. 24). This is echoed in Harris *et al.'s* (2000) work which suggests nursing work that is easily captured by the scientific reasoning process will be easily captured by computerized systems.

Although it seems straightforward that perhaps nursing knowledge which is readily coded will be the nursing knowledge that is available for use in nursing decision support systems, there are remaining issues with integrating this knowledge base as well. In their review of nursing languages, Henry *et al.* (1998) note that none of the existing nursing vocabularies meet all of the Computer-based Patient Record Institute's (CPRI) criteria for classification systems for implementation in an EHR.

Conclusion

Expert systems designed for the nursing profession have not gained wide use in spite of overall positive attitudes of nurses towards such decision support tools documented in the literature. In a study by Gardner and Lundsgaarde (1994), physicians and nurses rated access to patient data and clinical alerts highly in CDSS. Neither group felt that computerized decision support decreased their decision-making power. The study findings indicated that nurses embraced expert systems as useful tools as much as their physician counterparts. Meyer *et al.* (1996) also found enthusiasm among nurses and initial results of the use of a nursing expert system were positive but subsequent analysis identified significant limitations of the system to mimic the consultation process of advanced practice nurses. Such challenges, associated with the design and implementation of expert systems for nursing, have been discussed in this paper. It becomes evident that computerizing nursing knowledge is not an effortless process. However, the holistic focus of nursing should not be viewed as an impediment to the diffusion of expert systems for the nursing profession. In spite of this and additional challenges highlighted in this paper, nursing expert systems can improve the overall quality of care when designed for the appropriate end-user group and based on a

knowledge base reflecting nursing expertise. As is the case with all expert systems, they should be viewed as useful tools for a specific target group and not products that replace the decision maker, nor aim to simultaneously aid all professional groups and all levels of knowledge workers. Organizational support for both nurses and nursing practice is a critical component for successful implementation of clinical decision support systems. We recommend further development of nursing CDSS with input from nurses. Such development should address the differing information and knowledge needs of various practice levels. Additionally, nurses chosen to participate in CDSS implementation teams should possess the same attributes as skilled nursing preceptors, namely, domain expertise and an understanding of the different needs of nurses with various practice levels. Continuing research in encoding nursing information and knowledge such as nursing language development will further support the development of CDSS for nursing.

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Table 1

Nursing practice levels and clinical decision support systems (CDSS) implementation implications

Practice level	*Practice description*	*CDSS implementation implication*
Novice/advanced beginner	Focus on the immediate needs for action for a clinical situation based on rules, protocols and practice	Nurse Receptive audience CDSS Assist with task organization Provides guidance for action for unfamiliar situations May be limited in distinguishing subtle difference in clinical situations
Competent	Crisis in confidence in their environment and focus on goal setting and time management	Nurse Increased skepticism of system comprehensiveness CDSS Provides structure for goal setting, care plans or care trajectories Assists with standardizing practice May limit professional growth beyond standard practice
Proficient	Understands situational and establishes situation-specific priorities	Nurse May not be receptive to prescriptive systems that do not recognize situation specific challenges Could provide valuable clinical knowledge and experience to design and implementation teams CDSS May not further enhance clinical practice
Expert	Immediately grasps familiar situations and recognizes when he or she does not have a good grasp of a situation	Nurse Difficulty in articulating expert practice knowledge but could provide practice narratives to assist with system development May not be an appropriate audience for CDSS CDSS May not further enhance clinical practice

Table 2

Key issues and recommendations for nursing managers and administrators

Issue	*Recommendations for nursing managers and administrators*
User participation	Nurse managers and administrators can invite nurses to participate in needs assessments and implementation planning. Staff nurses can participate through identification of: Key nursing concerns Informational needs and expectations Critical workflow issues such as providing descriptions of the workflow patterns of their unit and interdependencies between systems Nurse managers and administrators should consider providing additional coverage while nursing staff are involved in system development and training as well as system implementation to encourage staff participation
Human computer interaction	Nurses should be invited to participate in testing and actual implementation of the system Staff nurses can participate by: Test an application in a lab situation prior to wide-scale implementation Provide feedback on anticipated workflow issues as a result of implementation such as need for increased staffing levels at first or placement of the system within the workspace Nurses with an aptitude for the system can serve as preceptors or ‘power users’ for their units
Systems integration	Nurse administrators can purchase or recommend purchasing systems that Integrate with existing information systems such as EHRs or laboratory systems in order to reduce redundant documentation Utilize a standardized nursing language for organizational comparisons
Encoding challenges	Nurse managers can: Invite expert nurses to provide practice narratives to help system designers tap their clinical knowledge Facilitate nurses working with system designers to describe unit or clinic specific scenarios