



# Design and Implementation of Real Time Embedded Tele-Health Monitoring System

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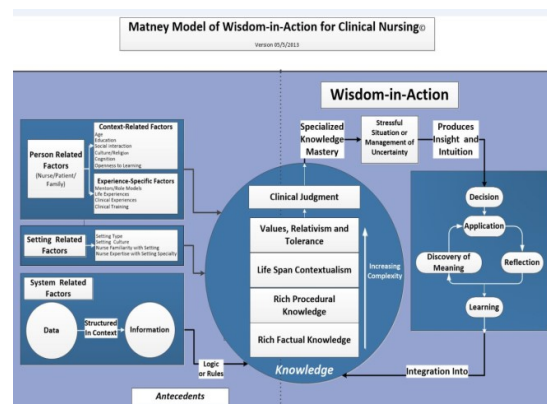
**Abstract:** - In the mid-1980s Blum (1986) introduced the concepts of data, information, and knowledge as a framework for understanding clinical information systems and their impact on health care. Blum classified clinical information systems according to the three types of objects that these systems processed: data, information, and knowledge. Blum noted that the classification was artificial, with no clear boundaries, although they did represent a scale of increasing complexity. In 1989, Graves and Corcoran built on these ideas in their seminal study of nursing informatics using the concepts of data, information, and knowledge. They contributed two general principles to NI: a definition of nursing informatics that has been widely accepted in the field and an information management model that identified data, information, and knowledge as key components of NI practice. Data, information, and knowledge are of value to nurses in all areas of practice. Data may be obtained from multiple sources, such as individuals, families, communities, and populations. Data are then processed into information and then into knowledge. For example, data derived from direct care of an individual can then be compiled across disease states and then aggregated for decision-making by nurses, nurse administrators, or other health professionals. Further aggregation can encompass geographical populations. Nurse-educators can create case studies using these data, and nurse-researchers can access aggregated data for systematic study. The appropriate use of knowledge involves the integration of empirical, ethical, personal, and aesthetic knowledge into actions. The individual must apply a high level of empirical knowledge in understanding the current situation, apply a professional value system in considering possible actions, be able to predict the potential outcome of these actions with a high level of accuracy, and then have the means to carry out the selected action in the given environment.

**Key terms:** tele health, health monitoring, electronic measurements, ECG, Bi-medical.

## 1. INTRODUCTION

Wisdom is defined as the appropriate use of knowledge to manage and solve human problems. It is knowing when and how to apply knowledge to deal with complex problems or specific human needs (Nelson & Joos, 1989; Nelson, 2002, Nelson & Staggers, 2014). While knowledge focuses on what is known, wisdom focuses on the appropriate application of that knowledge. For example, a knowledge base may include several options for managing an anxious family, while wisdom involves nursing judgment about which of these options is most appropriate for a specific family, and the use of that option in

the care of the family. Nursing wisdom is a concept that requires specification of the consequences of actions (which are selected by the nurse) as one of its defining characteristics (Walker & Avant, 1994). Representation of the complexity of wisdom in nursing databases must include not only the nursing problem to be addressed, but also the need for the nurse to select among a variety of interventions to address the problem, and the evaluation of those interventions and outcomes.



Current system limitations infer that although data, information and knowledge can be built within the electronic health record, the concept of wisdom can only occur with a human caregiver who has the ability to interpret the data, information, and knowledge presented. This individual is responsible to recognize the appropriate action needed in a given situation. Decision support serves as a guide, not a solution. Wisdom is the overall ability to make the correct decision for a patient by acknowledging and reflecting that individual's needs and preferences at a specific point in time.

Benner (1984) defined the experiential stages of the nursing professional in *Novice to Expert: Excellence and Power in Clinical Nursing Practice*. Nelson and Englehardt (2002) integrated the inclusion of the wisdom into their model. Benner, Hooper-Kyriakidis and Stannard (2011) have brought Thinking-in-Action as an approach to administration of care. Now Matney has completed the loop with the model of wisdom-in-action. Wisdom embodies the art, science, and spirit of nursing. The nursing Informatics specialty embodies the nurses' passion for caring, with the ability to use data,



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information, knowledge, and wisdom to improve individual patient outcomes via evidence-based practice.

The addition of wisdom raises new and important research questions, challenging the profession to develop tools and processes for classifying, measuring, and encoding wisdom as it relates to nursing and informatics education. Research in these directions will help clarify the relationship between wisdom and the intuitive thinking of expert nurses. Such research will be invaluable in building information systems to support healthcare practitioners in decision-making.

Data are measurements collected at single instances. Information emerges when data are organized and placed in context. Knowledge reflects the increased complexity, interactions, and relationships that must be analyzed and addressed so that the meaning is understood. After application of knowledge in context, if the nurse reflects, learns and puts new knowledge into practice, that's one form of wisdom. Similarly, wisdom comes with experience upon which the recognition of pertinent data is ingrained into practice, actions are developed into best practices, and that knowledge is shared with others.

For example, if a nurse receives the following list of numbers, 28, 68, 94, 98, and 110, the raw numbers are certainly “data”, but they are meaningless. If, however, the numbers are ordered, structured, and identified as follows: T 98°, P 94, R 28, and BP 110/68, they are obviously vital signs (VS) and every nurse will recognize those numbers as information. However, for these numbers to have meaning, the nurse must be able to place them in the context of a particular patient's situation in order to interpret the meaning of those numbers. If these vital signs were obtained from a newborn, they mean one thing, but if they were obtained from an adult, they mean something very different. The nurse's knowledge of normal VS values for different types of patients, and the condition of the patient from which the numbers were obtained, provides a context within which the nurse can interpret the numbers. Then the nurse will know if the numbers represent a normal, expected result or an abnormal, even pathological result. The numbers are now placed in a particular context so that the nurse can take appropriate clinical action, thereby demonstrating “knowledge-in-use” or wisdom.

## 2. THE INTEGRATION OF NURSING INFORMATICS

Data, Information, knowledge, and nursing wisdom, are central to healthcare delivery. Nurses are skilled in managing and communicating information and are concerned with content quality. Nursing informatics is also concerned with the creation, structure, storage, delivery and re-use of nursing and clinical information along the continuum of care. As health information systems are integrated into every nursing role, the use of technology at the point of care delivery; the external use of clinical information for quality, legal, and regulatory

activities; and the use of analytics of data and metadata contribute to the creation of new nursing knowledge.

Such an evolution in the healthcare environment contributes to the blurring of the boundaries between the roles of nurses and informatics nurses. Defining the roles of the informatics nurse (IN) and informatics nurse specialist (INS) is a dynamic process that helps identify commonalities and distinctions in the practice continuum for nurses at all levels and specialties is a dynamic process.

The informatics nurse (IN) is a registered nurse with an interest or experience in an informatics field, most often identified as nursing informatics. The informatics nurse specialist (INS) is a registered nurse with formal graduate level education in informatics or related field. Each employs their unique informatics knowledge, experience, and skills to enable other registered nurses to best use information and technology in their practice domain. The range in that use of information and technology can be visualized on a continuum.

## 3. HUMAN-COMPUTER INTERACTION AND RELATED CONCEPTS

Human-computer interaction (HCI), usability, and ergonomics are concepts of fundamental interest to the informatics nurse. Essentially, HCI deals with people, software applications, computer technology, and the ways they influence each other (Dix, Finlay, Abowd, & Beale, 2004). Elements of HCI are rooted in psychology, social psychology, and cognitive science. However, the design, development, implementation, and evaluation of applications derive from applied work in computer science, a specific discipline (in this case nursing), and information science. For example, an informatics nurse would assess a medication ordering application before purchase to determine whether the design complements the way nurses cognitively process orders.

A related concept is usability, which deals with human performance during computer interactions for specific tasks in a specific context. Usability is a quality attribute. It describes how easily the user can interface with the machine and can refer to methods for improving efficiency and effectiveness in the design process (Nielsen, 2012). An informatics nurse might study the ease of learning and use of an application, the speed of task completion, or errors that occur during use to determine which system or application would best fit a nursing unit.

The term ergonomics typically is used to describe the design and implementation of equipment, tools, and devices to promote human safety, comfort, and productivity (Hannah, Ball, & Edwards, 2006, as cited in Alexander, 2011). Commonly, the term ergonomics refers to attributes of physical equipment or to principles of arrangement of equipment in the work environment. For instance, an informatics nurse may have a role in ensuring that sound



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ergonomics principles are used in clinical settings to select and arrange various devices to support workflow for inter professional providers, patients and their families, and other end users.

HCI, usability, and ergonomics are typically subsumed under the rubric of human factors, or how humans and technology relate to each other. The overall goal is to design software, devices, and equipment to promote optimal task completion. Optimal task completion includes the concepts of efficiency and effectiveness and also considers the safety of the user (Rogers, Patterson, Chapman, et al, as cited [Henriksen, Battles, Marks, et al, 2005]). The informatics nurse and informatics nurse specialist must understand all of these concepts to successfully develop, select, implement, and evaluate information structures and informatics solutions. Stagers (2003) identified the interrelationship of HCI, ergonomics, and usability as described in Figure 9.

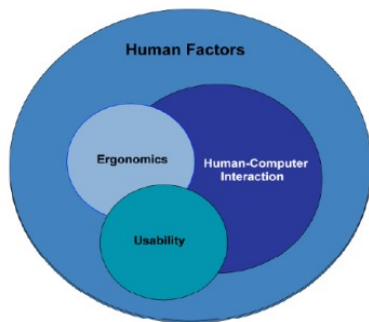


Figure.1. Human Factors Relationships (Stagers, 2003)

The importance of human factors in health care was elevated with the Institute of Medicine's 2001 report. Following this report, the number of HCI and usability publications in health care has increased substantially. Vendors installed usability laboratories and incorporated usability testing of their products into their systems lifecycles. The FDA mandated usability testing as part of their approval process for new devices in 2007. Thus, HCI and usability became critical concepts for informatics nurses to understand. Numerous usability methods and tools became available, such as heuristics (rules of thumb), naturalistic observation, and think-aloud protocols.

In 2006, the Technology Informatics Guiding Educational Reform (TIGER) Initiative was established with the goal of enabling nurses and nursing students to fully engage in the use of technology (<http://www.thetigerinitiative.org/>). The TIGER Initiative promotes understanding by nurses in identifying information/knowledge management best practices and effective technology capabilities for nurses.

The Initiative was followed in 2009, by the American Recovery and Reinvestment Act (ARRA) that ushered in several initiatives that encouraged the use and development of technology by nurses and other healthcare professionals

(HealthIT.gov, n.d.; Alpay, 2011). The integration of technology into everyday life has contributed to the empowerment of patients, now often designated as e-patients. The combination of these factors increased the significance of HCI. Currently, the development and use of healthcare applications for mobile technology (m-health) will intensify the need for the informatics nurses to understand HCI concepts and engage in a participatory development process that will include vendors, patients, and healthcare professionals.

A subsequent report by the IOM in 2012 entitled *Health IT and Patient Safety: Building Safer Systems for Better Care* identifies the importance of HCI in the integration of technology with healthcare delivery. The expanded use of HIT promotes interprofessional development and collaboration, as well as patient involvement in the utilization of healthcare devices. This will require the INS to address all environments and all levels of user ability to accommodate the various devices being developed for use. The INS will also need to consider a variety of socio-technical issues and their effect on HCI (Sittig & Singh, 2010). These include clinical experience level (Cho, Stagers & Park, 2010), user literacy and user's physical limitations (Huang, Chen, & Chung, 2005), and aging (Sibley, 2008). In the future, the convenience of technologies available in commercial products can be expected to drive similar functionality in healthcare technology (Hardin, 2013) and will increase the scope of HCI factors. Finally, the effect of natural language processing (Zhou, 2007) and implantable monitoring devices (Topol, 2011) on HCI is yet to be determined.

#### 4. PHENOMENA OF NURSING

The met paradigm of nursing comprises four key concepts: nurse, person, health, and environment. The phenomenon of nursing, both art and science, is supported by the tenets of nursing informatics. The nurse continuously collects data about persons, their health, and the environmental factors that influence health maintenance and the healing process. Nurses, using their education, intellect, and experiential knowledge, place these data into categories to create information. Finally, using critical thinking and wisdom, the nurse is able to formulate a plan and prioritize interventions or actions that affect the greatest positive outcome for the situation.

Nurses make decisions from their unique perspectives based on their education, experience, and specialty. Decision-making is the process of choosing among alternatives. The decisions that nurses make can be characterized by both the quality of decisions and the impact of the actions resulting from those decisions. As knowledge workers, nurses make numerous decisions that affect the life and well-being of individuals, families, and communities. The process of decision-making in nursing is guided by the concept of critical thinking. Critical thinking is the intellectually disciplined process of actively



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and skillfully using the best evidence and using that knowledge to conceptualize, apply, analyze, synthesize, and/or evaluate data and information as a guide to belief and action (Adapted from Scriven & Paul, 1987).

The nursing process of assessment, diagnosis, outcomes identification, planning, implementation, and evaluation can be enhanced through the utilization of technology. Technology, when properly developed and applied, has been shown to enhance the healthcare team's ability to collect, categorize, interpret, manage, and share relevant information. This enhances the ability of the team to manage client care in a more efficient and productive manner. In most cases, the utilization of technology has decreased the workload of the nurse in collecting and categorizing data, while enhancing the sharing of relevant information with other members of the healthcare team. It is theorized that when the complexity of information sharing is decreased, enhanced sharing of relevant information within the healthcare team improves quality and safety and results in improved patient outcomes. The informatics nurse is ideally suited to evaluate how technology can assist the nurse and other members of the care delivery team to manage data and share information to achieve desired outcomes.

In addition to enhancing the nursing process, data collection, information sharing, intervention implementation, and resultant patient outcomes can be tracked via database queries and processed through research methods. It is through this research that evidence based practice models can be developed. These models of practice will then be supported by systems optimized to allow seamless data capture, intuitive data display, expert system processing, and positive patient outcomes.

Nursing is focused on optimizing the health status of individuals, families, communities, and populations. Each of these entities is affected by the environment in which it resides. Technology, when properly designed and implemented, enhances the ability to track and trend data to help determine where, how, and why resources need to be allocated to achieve the greatest good, while using the least amount of resources. Informatics nurses are uniquely qualified to assist in the development and optimization of systems that capture, categorize, share, and evaluate data and information while keeping the nursing process as the foundation of practice.

## 5. CONCLUSION

Informatics nurses and informatics nurse specialists apply informatics knowledge and skills to serve as a transformational leader and resource for clients, both formally and informally, in external and internal settings. Informatics nurse consultants must have solid expertise in clinical nursing and areas such as process redesign, strategic IT planning,

system implementation, writing informatics publications, evaluating clinical software products, working with clients to write requests for proposals, performing market research, and assisting in the planning of conferences, academic courses, and professional development programs. These expert INSSs may work for a consulting firm, be employed as staff of the organization where they consult, own an independent practice, or are recognized as an expert by writing about NI and speaking at NI-related events. Flexibility, good communication skills, solid nursing/healthcare delivery background, breadth and depth of clinical and informatics knowledge, and excellent interpersonal skills are needed to respond to rapidly changing projects. **Operational Architecture** - A data management process that enables a responsive end-to-end healthcare information environment: (1) where information exchange processes are transparent and actionable; (2) the means to produce, exchange, and use information is protected; and (3) where resources are allocated based on operational requirements and implemented through the use of precedence, priority and resource allocation techniques.

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