

## The Nurse—Patient Trajectory Framework

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### Abstract

*The development of nursing knowledge should give structure and form to the practice of nursing. The development of Nursing Process Theory resulted from early nursing observations and inferences from nursing practice that resulted in formal data accumulation processes, mutual correspondence between nurses and patients, and exchange of information. The development of the nursing process discipline helped to substantiate the need for professional nursing services. The shifts towards examining the links between processes and outcomes, professional accountability, and classification of distinct nursing functions have influenced the development of information systems. The Nurse—Patient Trajectory Framework described in this paper may be used to show the relationships between the virtual information system and the real world that it affects. The framework is visualized along two separate and distinct nurse and patient trajectories.*

### Keywords:

nursing informatics, information systems, nursing process

### Introduction

Nurses and patients interact with computers on many levels. Staff nurses collect information from their clients and, in some cases, simultaneously store client information in information systems. Nursing administration or researchers can use the information contained in this warehouse of data to evaluate utilization, financial impact, and risk management activities of nursing services. The information can also be used to maintain an ongoing record of events, actions, behaviors, perceptions, and progress made during healthcare encounters. Effectiveness of nursing information systems to understand and predict nursing and patient outcomes depends on the usability of the system, organizational workflow, and satisfaction during nursing interactions with computer information systems. Therefore, understanding interactions between nurses, patients, computers, and other elements of information technology has the potential to improve nursing care processes and, subsequently, patient outcomes impacted by nursing services. The following paper describes a framework for nursing informatics (NI) called the Nurse—Patient Trajectory Framework. The framework utilizes nursing process theory, human computer interaction, nursing and patient trajectories as components of a framework that can be used to evaluate patient care systems.

### Background

#### Nursing process theory

Nursing, as a practice discipline, should be concerned with the development of nursing knowledge and nursing knowledge should be used to give structure and form to the practice of nursing [1]. From the roots of the beginning of professional nursing education the nursing process was taught as a means to structure nursing care. Original components of Nursing Process Theory were developed through extensive clinical observations and evaluations of nurses performing the nursing process [2-3]. Emphasis on these clinical observations and inferences made from nursing practice was seen as a forerunner to the nursing process, with its respective components being precursors to a formal data accumulation process [3]. In early anecdotal observations emphasis was placed on the importance of reciprocal relationships between patients and nurses and the importance of the process of nursing care. The nursing process represented the first attempts to develop reciprocity between patients and staff. Reciprocity was garnered through mutual correspondence between patient and staff, through mutual exchange of privilege, and through the mutual dependence, action and influence the patient and staff have on one another.

The four practices basic to the nursing process, as recognized by Orlando [2], were observation, actions, reporting, and recording (Figure 1). Observations included direct or indirect information obtained about a patient while on duty. Direct information was derived from the nurse's own experience of patient behavior. Indirect information included reports of actions, records, or reports of other nurses or allied health professionals. Actions, such as the ability to make decisions or planning care, occur within a context and environment. These contexts are highly influenced by organizational design, area of application, characteristics of the decision maker, maturity of the setting, and importance of the decision [4]. Finally, recording and reporting of nursing information regarding observations and actions is a fundamental function of nursing practice. The effectiveness of nursing process is dependent upon the clinical inferences made from information captured. Every clinical inference made involves an element of risk for the nurse, patient, and the relationship between them [3].

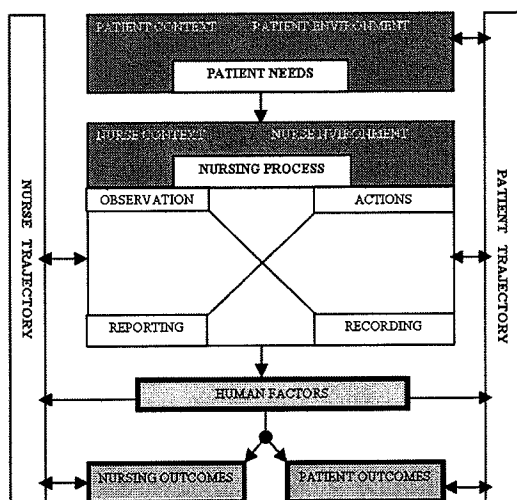


Figure 1 - The Nurse-Patient Trajectory Framework

### Nursing informatics: creating the interface between nursing process and technology

Werley and Grier, two pioneers in nursing informatics, advocated for the development of nursing information systems (IS) [5]. Their work led to the identification of nursing data elements essential to diagnosing nursing problems, choosing nursing actions, and evaluating the nursing process in electronic health records (EHR). Furthermore, they suggested research directions to promote the development of technology in caregiving activities. Finally, Werley and Grier published one of the first nursing models that established a link between IS and the development of nursing knowledge.

Their model integrated community data, institutional data, interpersonal data, and patient data into a hierarchical framework. It was suggested that these information sets were needed to assist nurses in making decisions at various levels of functioning [6]. Sets of information thought to be important to nursing decisions included aggregate data on communities including population risk, cultural status, institutional data on finances and structure of facilities, interpersonal elements of caregiving including nursing interventions, orders, and outcomes, and finally, patient data including diagnoses, psychosocial factors, and patients' perceptions and goals. Facets of this systems model approach can be seen in subsequent NI frameworks [7;8].

Schwirian developed the NI pyramid as a model for Nursing Informatics [9]. Schwirian defined NI as, "the use of information technology in relation to any of the functions which are within the purview of nursing and which are carried out by nurses." (p. 134). NI activity was depicted as an interface between the computer hardware and software, raw nursing related information, and the user within the context of their profession or organization. All of these elements led to a common goal or objective. The model is described as being flexible and multidimensional allowing the researcher to

enter into the model at various points depending on the research questions and hypotheses posed.

Graves and Corcoran [10] defined NI as a, "... combination of computer science, information science, and nursing science designed to assist in the management and processing of nursing data, information and knowledge to support the practice of nursing and delivery of nursing care" (p.15). These authors emphasized the processing of nursing information as it progressed from data to information, and finally, to nursing knowledge. In a related article, Goosen [11] extended Graves and Corcoran's NI model to include decisions made in clinical practice, activities that follow nursing decisions, and in the final evaluation, consideration of patient outcomes. These models emphasized the importance of understanding how nurses utilize information to develop knowledge. Goosen went one step further to include pragmatic aspects of information or how information leads to nursing actions.

Turley [12] described a model for NI based on three themes derived from past definitions of nursing informatics. The themes regarded the use and the position of the computer and computer science in informatics, conceptual issues, and functional performance in informatics. These themes underscored the important role computer technologies play in the daily functions of nurses. The model utilized nursing science as a base of knowledge to promote the advancement of nursing informatics as a discipline. Computer science, information science, and cognitive science were represented as spheres in the model that overlay nursing science. The juncture between the three spheres represented the informatics domain. Computer science represented the development of hardware and software to facilitate new understanding and new ways of representing knowledge. Information science facilitated knowledge of organizational structure and informational flow through the organization. Finally, Turley indicated that cognitive science helps to clarify information technology by improving information retrieval, perception of information encountered, and understanding of information processing. Stagers and Parks [13] developed a model called the Nurse—Computer Interaction Framework which has been used to help understand interactions between nurses, computers, and enabling elements that optimize the ability of nurses to process information via computerized systems. The authors identified five elements commonly included in human—computer interaction (HCI) frameworks including the user, computer, tasks, interfaces, and environmental elements. After a review of several frameworks the authors reached several conclusions regarding previous NI frameworks including: 1) most frameworks lack environmental and task oriented elements that are essential to understanding computer interactions, 2) elements of frameworks are conceptualized differently across different frameworks, and 3) most frameworks do not include a dimension of time.

Stagers and Parks [13] included a developmental trajectory for NI including time dimensions not previously developed in NI models. According to the model the NI trajectory has important implications because: a) nurse—computer inter-

actions can change over time and b) the location of phenomena along the trajectory has important implications for outcomes related to nurse—computer interactions.

The most recent model of NI described by Effken [8], the informatics research organizing model (IRO), extends Donabedian's structure—process—outcomes model and emphasizes elements of Nursings' metaparadigm including the system, nurse, patient, and health. Effken described the IRO model as being highly abstract and as being able to accommodate various middle range theories and conceptual frameworks. Effken indicated that all organizing frameworks for NI must address and represent two essential components including context and components of nursings' metaparadigm. Based upon these criteria, previous frameworks for NI were found to exclude specific elements of these essential components. According to Effken, some of the current NI models do not explicitly make the patient part of the model, while other models do not define the context or include all elements of nursings' metaparadigm.

### **Nurse-patient trajectory framework**

Previous NI models have been criticized for not explicitly including aspects of patient care but, being more about nursing management than patients [8]. As discussed previously, reciprocal relationships between patient—nurse, nurse—nurse, and the nurse—significant other are integral components that need to be included in the clinical decisions made by nurses. Evidence of these relationships is represented in the knowledge gained through interactions between these individuals. These interactions facilitate an exchange of communication between patient and nurse that lead to better understanding of the contextual and environmental factors attributed to each person. Crucial factors that must be recognized in shared information are cultural, social, economic, and physical characteristics; excluding this information interferes with the ability to fully understand potential outcomes of a patient [8]. Including this information can facilitate more effective nursing actions that can lead to better individual outcomes along nurse and patient trajectories.

### **Defining nurse and patient trajectories**

The term trajectory in health care can be defined as the assembling, scheduling, monitoring, and coordinating of all steps necessary to complete the work of patient care. The term trajectory refers not only to the pathophysiological process of a patient's disease state, but also refers to the total organization of work done throughout all nurse and patient interactions and refers to the impact of patient care processes on those interactions and the organization [14;15]. Trajectories involve different medical and nursing actions by people with different types of skills and resources, trajectories lead to a separation of tasks between workers, including kinfolk and the patient, and trajectories must consider the different relationships between all workers [15].

Two separate trajectories, the nurse trajectory and patient trajectory, are identified in the proposed framework (Figure 1). While appearing to be in parallel with each other these trajectories could be viewed as quite independent of

each other. Associated with each trajectory is a trajectory scheme that can be imagined as a sequence of potential events or anticipated events along the trajectory [15]. The beginnings of the trajectory may have two different dimensions for the nurse or patient. The nurse may characterize the diagnosis or chief complaint as the beginning of the trajectory. A patient's trajectory may begin when a symptom or a need appears before coming in contact with a health care professional.

The patient's context and environmental characteristics are also seen as separate and different from nursing context and nursing environment. Context has been described as a multi-layered construct that has cultural, economic, social, and physical implications for understanding potential and actual outcomes [8;13]. These actual and potential outcomes are associated along two trajectories, one for nursing and one for patients. The potential and actual outcomes are affected by how technology is integrated into the environment and by the user's ability to interact with technology.

### **Nurse trajectories**

Nurse trajectories begin when the diagnoses or chief complaint is determined. Nursing contexts are described in the observations, actions, reports, and records of nursing information. Patient behaviors and perceptions of the nurse that is described in the context of the nursing data influence clinical decision making. Decisions may be influenced by accessibility of information, how information is classified and stored, how it is communicated, how technology is used, and design of workspace including both physical and virtual environments (Salvendy, 2005). Finally, a set of nursing outcomes is identified on the nursing trajectory. While these nursing outcomes may certainly overlap with patient outcomes (i.e. patient safety) the implications for nursing will be different than for the patient. For example, if a nursing process is changed related to medication administration practices the nurse might require education of new policy changes and possibly competency evaluation while the patient only knows that they have received the right medication, just in time and at the right dose.

In contrast to those who attempt to define the nursing process through more descriptive measures, other evaluations of nursing processes using EHR center on quality of documentation, patient satisfaction, and nurse perceptions. Evidence of the benefits and the lack of benefit of IS that incorporate nursing documentation and case management strategies have been reported [16-18]. Nahm and Poston evaluated an integrated point of care systems effect on nursing documentation. The authors identified several attributes of computerized IS that contribute to quality documentation including: a) prompts or reminders within assessments and interventions to alert nurses to required documentation, b) ability to collect real time nursing data, c) standardized, streamlined assessments and interventions in menus and interfaces, d) mandatory fields requiring nursing attention before the nurse can proceed, e) information retrieval from past visits, and f) incorporated work tools that sequence and consolidate tasks and provide reminders when part of the nursing process is missed [16].

The authors also found that computerized documentation did not interfere with patient satisfaction.

In another study evaluating nursing documentation pre- and post-implementation of IS the authors found that IS did not significantly improve documentation within the first 6 months of the study [17]. However, with re-education of nurses on the use of IS documentation of assessments of outcomes, goals, and nursing interventions performed did improve by the end of the 18 month post-implementation phase[17]. Nurse perceptions of clinical information systems were evaluated to determine different views between computer users and non-users about how IS affected their practice [19]. Interestingly, this study indicated that there was a significant difference between the two groups when asked about satisfaction and professional status with computerization. Nonusers were less satisfied because they felt the computer interrupted their thought processes, they felt they could not trust the computer, and they felt the computer thought too much for them resulting in a reduced professional status[19].

#### **Patient trajectories**

Patient trajectories may begin with an identified need or symptom and are dependent on a separate set of contextual and environmental factors than healthcare workers. Patient trajectory schemes may be well developed and thought out before they even have any contact with healthcare providers. At the onset of the identified need or symptom patients may begin accessing healthcare information via the World Wide Web or other sources so that they are armed with information for the healthcare worker by the time the diagnosis or chief complaint is made.

There are cultural, economic, social, and physical considerations within the context of the patient environment that shape the patient trajectory[7]. For example, a patient's physical location can have implications for the availability of medical technology or other sources of health care such as information on the Internet. Patient trajectories may also be influenced by past personal experiences or by relationships with other people with similar needs.

#### **The use of technology to evaluate nurse-patient trajectories**

Technology can influence trajectories by producing an entirely new trajectory or by lengthening trajectories[15]. New trajectories are created when medical information, that was previously difficult to find, is found with a simple keystroke, with an automated computer alerting system, or by creating color changes in critical text fields holding vital clinical information. The new information may lead to different clinical decisions or judgments regarding treatments, potential outcomes, diagnoses, or utilization of health care resources.

The lengthening of trajectories creates new medical, organizational, and personal problems for patients who are living longer than expected and thus have more complex illnesses and trajectory schemes. Lengthened trajectories may lead to increased specialization, costs, and oftentimes

uncertainty of outcomes. Although, research on nurse and patient trajectories is limited some research exists that can be used to describe trajectory evaluation[20-22].

#### **Nurse-patient perceptions and human-computer interaction**

The complexities of organizing therapeutic actions are derived from the multiple trajectories, the range and number of complex tasks, which affect the course of patient care and the organization of those tasks [14-15]. The ability of nurses to perceive and organize their work in IS depends on how nurses interact with the computer systems.

Human computer interaction (HCI), oftentimes used interchangeably with usability or human factors, addresses specific issues of human performance during computer interactions including ease of learning, use, remembrance, satisfaction, efficiency, error-forgiving interactions, and seamlessness of fit to tasks [23]. Previous research has shown that IS can provide benefits by seamlessly linking homebound persons with Alzheimer's disease and caregivers with information resources, online health related support, and training [7]. The information system was found to provide strong interpersonal support [7]. This type of early intervention via a computer linking patient, caregiver, and healthcare provider will allow for earlier intervention by nurses in the patient trajectory scheme and may improve patient outcomes.

In other studies, research has shown that understanding the interface between users and the information system plays a role in nurse-patient trajectories. Healthcare providers are challenged by the availability of information at the point of care. In a study, designed to discover and implement design principles to facilitate healthcare practitioners access to healthcare information, a strong correlation was found between total time, navigational ability, and perceived functionality within a computer interface[24]. Ability to find accurate information on which to base decisions can affect the ability of nurses to provide care that is evidence based. Further studies have shown that by reducing the barriers to the use of clinical reminders, such as usefulness, workflow, and efficiency, quality of care of inpatients may improve [25].

#### **Conclusion**

The purpose of a framework or a model is to show varying degrees of relevance between virtual or imagined systems and the real world it represents [1]. The purpose of this paper is to describe a framework that incorporates the fundamental components of nursing, the nursing process, with principles of human computer interaction. The framework can be visualized along two separate and distinct trajectories, nurse or patient, which ultimately, depending on the design of the information system, may impact nursing and patient outcomes.

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## System Analysis and Improvement in the Process of Transplant Patient Care

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### Abstract

*Clinical information concerning transplant patients is voluminous and difficult to manage using paper records. A system analysis was performed to assess information system needs of the liver, kidney, and pancreas transplant program at LDS Hospital in Salt Lake City, Utah. After evaluating workflow, decision support needs, and requirements, we designed and implemented an extendable information system to support care following liver transplantation. We developed and implemented a standardized operative note, forms to enter external laboratory results and transplant-related information into the electronic health record, and computerized alerts to notify the transplant nurses when liver transplant patients had new, abnormal, or overdue laboratory results. The information system has improved the quality of clinical data available in the EHR, clinician satisfaction, and efficiency with management of laboratory results. The components developed for this project can be extended to meet other transplant program needs.*

### Keywords:

system analysis, ambulatory care, transplantation

### Introduction

In the United States during 2005, 28,107 persons underwent solid organ transplantation for end-stage disease.[1] Long-term survival depends on the patient's clinical status, the surgical procedure, the donated organ, and the management of immunosuppressive therapy and complications. The process of evaluating patients, matching them with donors, and monitoring them after transplantation, generates large volumes of information from multiple sources. Physicians, nurses, and support staff that work with transplant programs need to manage and access this large volume of laboratory, clinical and other data to make decisions.

LDS Hospital, in Salt Lake City, Utah, has a liver, kidney, and pancreas transplant program that selects and monitors adult patients that reside in eight western states in the United States. LDS Hospital is 1 of 21 hospitals and numerous outpatient facilities included in an enterprise called Intermountain Healthcare (IHC). In 2004, 159 kidney, liver or pancreas transplant surgeries were performed at LDS Hospital, and 1,216 transplant patients required

outpatient monitoring. The volume of information managed by the transplant program increases each year as the annual number of transplantations increases and survival rates improve.[2] In 2000, the director of the transplant program at LDS Hospital requested assistance with developing "a database". Their information system was almost completely based on paper records. The transplant program could purchase or build a stand-alone information system, or they could integrate their needs with electronic record systems available at LDS Hospital.

The objectives of this project were to define the requirements for a transplant program information system, to identify a transplant process that could be improved with computerized information technology, to initiate system development, and to make a positive impact on patient care.

### Methods

Using a systematic approach [3], we addressed each software development phase and used our findings to inform the next phase. We performed a system analysis, requirements analysis, and defined a feasible project scope. The system was designed and developed using knowledge engineering methods, vocabulary development, and application programming. We performed usability testing and quality assessment on the new computerized components, implemented the system, trained the transplant team, and evaluated the impact and user satisfaction. Selected methods and results are reported.

### System analysis

System analysis is important for understanding problems, directives, and opportunities; establishing priorities; and assessing feasibility.[4] Before expending resources, the following questions needed answers. What information was needed to manage transplant patients? Who needed information and from where will it be accessed? What processes would benefit from computerization? Workflow and information flow were assessed by attending weekly transplant meetings and observing processes in the office and clinic. Existing data forms, reports, and record systems were assessed. The medical, nursing, and support staff were interviewed to determine priorities and clarify the process of transplant patient care. We reviewed clinical