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## Review Paper

# *Nursing Informatics: State of the Science*

**Abstract:** Nursing informatics is a combination of computer science, information science and nursing science designed to support the practice and delivery of patient care. Using the informatics model of data, information and knowledge, the nature of automated systems to support clinicians in their delivery of high-quality care are described from their inception to their current state, and the importance of research to advance the state of nursing knowledge are emphasized. The evolution of clinical care systems and nursing management systems are viewed, as is the progress of the scientific work relative to nursing informatics. Milestones in the advancing state of the science are identified and the conclusion is drawn that although nursing informatics has evolved, much scientifically based work remains. Key nursing informatics resources identified in the paper support this conclusion about what remains to be accomplished.

**Keywords:** Nursing Informatics, Information Management, Nursing Research

### Introduction

A nursing informatics definition with widespread acceptance by the nursing community guides this review ([1] p. 227). Graves and Corcoran identify nursing informatics 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 and delivery of nursing care. According to the definition, data are discrete entities that are described objectively without interpretation; information represents data that are interpreted, organized or structured; and, knowledge is information that has been synthesized so that interrelationships are identified and formalized.

Prior to the widespread acceptance

of this definition, the earliest nursing informatics publications consisted of reports of systems being developed and used for nursing care practice and for management of nursing care delivery. Subsequently, nursing informatics researchers began to question the usefulness and the efficacy of these information systems for identifying nursing data, information and, for discovering nursing knowledge. Together, these occurrences have shaped the scope and the nature of nursing informatics as we know it today. However, to describe the current state of the science of nursing informatics, it is necessary to examine its brief history.

### Historical Background

The major components of nursing

informatics have been clinical care systems, nursing care management systems, and nursing informatics research. An overview of these focal areas is necessary for comprehensively describing the scope of nursing informatics, both past and present, and the current state of the science. A chronology of the nature of automated clinical care systems is used to illustrate the progress toward systems that support nurses' clinical reasoning and decision-making.

A review of the automated nursing management systems, primarily workload-based staffing and scheduling systems, illustrates that despite widespread proliferation, their developers and users paid little attention to issues of comparable and standardized data, and thus contributed only minimally to building nursing knowl-

edge. In contrast, nursing informatics research has been responsible for proposing questions that constantly test the boundaries of nursing informatics and its role in discovering nursing knowledge. For example, one of the most widely known informatics efforts, the Nursing Minimum Data Set (NMDS) espoused by Werley, has since its inception focused on the importance of clearly identifying nursing data, and getting it included in health-care datasets.

Other important nursing informatics research topics, described and prioritized by an expert panel of the National Institute for Nursing (formerly the National Center for Nursing Research) in the National Institutes for Health of the United States Department of Health and Human Services [2], include: acquiring and delivering knowledge from and for patient care, investigating new technologies to create tools for patient care, integrating systems for better patient care and evaluating the effects of automated systems. These historical descriptions, when combined with information that reflects current progress in nursing informatics, constitute a comprehensive view of the state of the science of nursing informatics.

#### *Nursing Clinical Care Systems*

The earliest automated clinical care systems for nursing were described by Cornell and Bush [3]; Wesseling [4]; Mayers [5]; Cook and Mayers [6]; and, Werley and Grier [7]. While many of these early systems' efforts were generally nursing process and nursing task-oriented, others were primarily designed as general task-oriented systems that were useful to nurses [8-10]. Preliminary reports of these systems illustrate that they began as task-oriented patient care planning systems, but gradually evolved to problem-oriented systems based on standards of care that included problem identification and appropriate nursing actions.

However, as Hughes reports, the focus of systems usually reflected the overall task of nurses' documenting care, using standard care plans that allowed retrospective quality and concurrent nursing documentation audits. In contrast, at the same time, the Omaha Community Health Nursing System was being developed using a patient care problem scheme for both clinical care provision and management of nursing care ([12] p. 250). In the late 1960s and early 1970s computerized patient monitoring systems were introduced into intensive care units.

Although these early systems were task-oriented and designed for monitoring patients' physiological states automatically, they eventually included nursing care functions. For example, they allowed computation of deficits in fluid management, of medication dosages, scheduling of medications, and nursing notes documentation [13]. Designers of these systems were among the first to confront several important aspects of data identification and its presentation as information for safe, decision-supported nursing care.

This decision-support paradigm, with automated alert systems, has been reported subsequently in a variety of intensive care systems [14].

#### *Nursing Care Management Systems*

Some of the earliest nursing care management systems were developed for use in community health settings [15]. These community health systems were designed for identification and follow-up of high-risk infants [16], and for management of public health nursing agencies [12]. At the same time, nursing management systems for hospital in-patient settings consisted primarily of patient classification and acuity systems, nurse rostering, resource management and nurse scheduling systems [17, 18].

A comprehensive overview of the

workload-based staffing systems in an estimated 1,000 hospitals in North America in 1978, representing at best 25 unique systems was reported by Giovannetti in 1978 [19]. These management systems were the predominant automated nursing systems in many facilities. Unfortunately, these staffing and scheduling systems were used almost exclusively for nursing management purposes; little attention was paid to using them also for discovering nursing knowledge about management and deployment of nursing resources and, their effects on patient care outcomes. Few efforts were expended to illustrate the comparability of data across care settings for understanding such things as nursing resource use, staff mix and other workload-related issues of nursing management related to patient care. Thus, some of the most important work-setting variables for explaining quality of care, have heretofore not been investigated.

#### *Nursing Informatics Research*

As automated clinical care and nursing management systems were being reported in the literature, nurse researchers became concerned with identifying and computerizing databases relevant to nursing care, with plans for future development of information systems to assist with providing quality nursing care [7] and with developing nursing knowledge.

An early nursing informatics conference held in 1977 had three major components: a data identification component that eventually evolved as the Nursing Minimum Data Set (NMDS); an information component about computerized nursing information systems or other systems available to assist nurses in systematically interpreting information; and a knowledge development component concerned with identifying research directions to promote development of information systems that assist in understanding

nursing care ([7] p. X). This conference's objectives translate to today's nursing informatics research concerns: those of identifying nursing data, information, and knowledge and using systems that provide support for nurse clinicians as they provide care.

A second invitational conference was held for the purpose of identifying the Nursing Minimum Data Set, defined as the essential body of nursing data needed to plan, organize, manage and evaluate nursing care ([20] p. XVII). Conference objectives were: to develop the NMDS in accord with professional standards of practice, and to establish the comparability of nursing data across clinical populations, settings, geographic areas and time, through consensual agreement on data categories, variables, and uniform definitions for these data in clinical, educational, administrative and research endeavors ([20] p. XX). An agenda to promote use, research and testing of the Nursing Minimum Data Set elements resulted from this conference.

The NMDS eventually became prominent internationally. The importance of identifying and collecting data with uniform and standard definitions has been recognized as central to current and future nursing informatics research efforts. Only when agreement is reached on data standards and definitions will it be possible to develop systems containing comparable data. These systems could then provide support for nursing practice, nurses' clinical reasoning and decision-making, and nursing management, thus fostering nursing knowledge discovery.

## Current Context for Nursing Informatics

The health-care informatics context within which the dimensions of nursing informatics exist today offers challenges that require simultaneous at-

tention to constantly changing health-care policy directions and to systems developers' technological responses to these changes. Nurse informaticians must remain aware of these important policy and technological interactions, and then inform the discipline with respect to evolving systems and about how the data and information can be used to support simultaneously the provision of care and the discovery of nursing knowledge. Likewise, nurse informaticians must also monitor a variety of external sources that affect evolving information systems, especially those currently emanating from national and international standards development organizations, and from initiatives such as the Computerized Patient Record Institute's (CPRI) computer-based patient record [21]. For example, the impact of the standards organizations on how clinical data are represented and communicated may well affect what data are available for use by nurse clinicians and for informatics research. Perhaps, clinical nursing data in narrative form (such as in nursing care plans or in nurses' notes) will not receive attention in clinical standards efforts, thus making it unavailable for exchange and communication. If these nursing care data are not available, it becomes impossible to make comparisons of care among different systems and different care settings. Additionally, if these important clinical nursing data and information have been excluded, nursing informatics development efforts could be severely impaired.

A similar scenario is possible if the clinical data represented in the computer-based patient record exclude the type and kinds of data required for evaluating the quality of clinical care and for discovering new knowledge. Each of these important issues is described next: the impact of continuing technological changes and health-care policy shifts, and the external pressures emanating from Standards De-

velopment Organizations and the Computer-based Patient Record Institute.

## Health-care Policy and Technological Interactions: An Example

The interdependence of health-care policy and systems design, and their interaction-like effects, are important to consider in describing the current state of nursing informatics. Continuing technological changes require constant system adaptations as they are planned and developed in an aura of ambiguity about what future health-care policies will demand. As changes occur in the health-care policy arena, systems development methods evolve in response to the anticipated changes.

Generally, this constant flux in both arenas (policy and systems development) remains quite imperceptible to all but experienced informaticians and informatics researchers. Clues are evident however, from gaps that are seen between what systems actually do and what developers claim for their next generation systems. An example of this policy and system design interaction illustrates that the policy shift involved prospective reimbursement for hospitals; the systems design principles involved a shift from the process-oriented approach to systems development with the adoption of a data flow-oriented approach.

Gabler [22] described three stages of systems design evolution as process-oriented, data base-oriented, and data flow-oriented. The flow-oriented approach concentrates on movement of data through the system and its use by different users and for a variety of purposes. The data flow-oriented approach is in contrast with either the process-oriented or the data base-oriented approach. Early information systems (i.e., process-oriented systems) were used to manipulate data and provide information such as laboratory and medication charge capture, ad-

mission and discharge information and other fiscal information, primarily for purposes of billing and recovering actual charges.

The second generation of systems, while still supportive of processes, was designed using a database focus, whereby demographics, diagnoses and treatment and procedures data could be examined from a variety of views. This database-oriented approach was necessary for assisting institutions in meeting the prospective payment policy requirements imposed by Diagnosis Related Groups (DRGs). However, since predictive models used data to project the best diagnostic combinations for maximal reimbursement, flow-oriented approaches to systems that included time dimensions became necessary. As a result, systems that could accommodate a data flow-oriented approach soon became essential because of the modelling required for prospective reimbursement policies. In summary, what resulted were system designs that gradually evolved to meet requirements imposed by policy shifts.

#### *Health Care Policy Changes*

The current gradual health-care policy movement toward capitated reimbursement regardless of care setting and outcomes-driven care (representing movement away from procedure-by-procedure reimbursement practices) has substantive implications for nursing informatics. Current policy directions represent an increased emphasis on efficient and cost-effective health-care across time and clinical encounters, resulting in measurable patient outcomes. These policy shifts continue to support the data flow-oriented approach to information systems development while also dictating some of the types of data for these systems.

Attention to policy directions and their impact on systems development and data requirements demand careful

attention from the entire nursing informatics community. Other noteworthy effects are also resulting from current health-care policy changes (i.e., health care reform) as the boundaries of care provision by type of provider are becoming less discrete.

Current health-care policy is heralding the return to an earlier paradigm of care documentation based on patient problems (i.e., a problem oriented approach), accompanied by a time-based continuum requirement (such as critical paths denoting expected patient progress over time), using recommended standards of care (i.e., clinical practice guidelines) and, with a requirement of evidence for cost-effective, quality of care and measurable patient outcomes. As a result, system developers are being forced to consider the inclusion of data that emphasize patient outcome measures, functional and health status measures, and documentation across a continuum of care that extends from home to acute hospital and back to the community or home.

Thus, the flow-oriented approach to data (i.e., single data entry at the source but used for multiple purposes), extending across the time continuum and across care service settings is now the center of attention for health-care information systems developers and users. The flow-oriented approach to systems development could be an important advantage for nursing informatics because the data needed for evaluating the continuum of care and quality of care is by its nature time-oriented.

Nursing's concern with documentation that provides evidence supporting high-quality continuity of care is long standing; the challenge becomes how to capitalize on such data in automated systems for both clinical care improvement and informatics research purposes. A critical issue for nursing informatics is how to ensure that the data, necessary for clinical care and

valid and reliable data for research, are represented and stored in systems so that information is accessible and available for both purposes.

#### *External Pressures for Nursing Informatics Standards Development Organizations and the Computerized Patient Record Institute (CPRI) Initiative.*

Several national and international standards developments that affect nursing informatics are underway and reported in *Next-Generation Nursing Information Systems: Essential Characteristics for Professional Practice* [23]. Currently, international standards initiatives are focused on vocabulary and syntax: the former referring to data definition and coding, the latter referring to the structure, communication and transfer of data. Syntax includes standards for computer architecture and "open systems," and communication standards for exchanging messages between systems. HL7, a protocol for the interchange of health-care data, is one example of standards for message exchange [24].

Vocabulary standards, for defining the contents of the messages and the coding of data within the messages hold the most significance for nursing. Important considerations include: how will nursing data be represented in the standards; and will nursing data definitions consist of rigidly defined terms (a controlled vocabulary) or will standards allow local flexibility and diversity while dictating higher-level term definitions and variable conformity.

While these vocabulary issues are under consideration by the standards groups, results to guide systems development efforts are increasingly available from informatics research on the Unified Medical Language System [25], nursing terminologies [26, 27], and the Unified Nursing Language System [28]. Classification efforts that incorporate coding schemes are also underway for nursing diag-

noses and interventions [29] and nursing interventions [30].

A community health nursing system, the Omaha System has a well-validated classification and coding schema for nursing problems, interventions and outcomes that is currently used in its automated information system [31].

At the international level, classification work is proceeding on a project to develop an international classification of nursing practice by examining the existing classifications and nomenclatures of nursing [32]. Grobe recently reported on the validity of a nursing intervention taxonomy developed using natural language methods, by comparing its seven categories to a large dataset of publications that included national and international classifications of nursing [33]. Ozbolt's current work on developing standard terms and codes for recording nursing care information in patient records is designed to permit relevant data to be abstracted into a shared database for effectiveness research [34]. She has developed a set of terms consisting of nursing diagnoses/patient care problems, expected patient outcomes, and interventions/patient care activities. Her work may serve as an important bridge to link with the ongoing vocabulary standards efforts. While these research efforts seem to be a partial response to the standards and computer-based records efforts, they only begin to address the data and information systems issues for the nursing informatics future.

### Nursing Clinical Care Systems: State of the Science

The proposed future generation of clinical nursing systems will exist within the context of a totally integrated, computer-based patient record [23]. While this may be perceived as

representing a shift away from earlier definitions of automated nursing information systems (as those that support primarily nursing activities), it represents increased maturity in nurses' recognizing the gradual movement toward an integrated patient record. What remains steadfast in nursing's view, however, is an underlying principle that any automated system for nurses' use must be based on current nursing practice standards. Nursing's eight standards remain constant for all settings and each addresses the management of data and interpretation of information for care.

Examples illustrate. The first standard states that the "*collection of data about the health status of the client/patient is systematic and continuous; and that the data are accessible, communicated and recorded.*" The eighth standard states that "*client's/patient's progress or lack of progress toward goal achievement directs reassessment, reordering of priorities, new goal setting, and revision of the plan of nursing care*" ([35] p. 3). While these standards originated in the 1970s, they seem to reinforce today's policy emphases on care outcomes and evaluation of the results of care, with an eye toward improving the quality of care so that patient outcomes are achieved using the computer-based clinical record and automated systems technology.

A timely set of guidelines for nurses and information system developers was created by a Task Force on Nursing Information Systems constituted by the National Commission on Nursing Implementation Project (NCNIP), in cooperation with the informatics specialty groups of the National League for Nursing and the American Nurses' Association in 1990. The guidelines, contained in a publication [23], resulted from an invitational conference of information system vendors' and nurses' discussions about the desirable characteristics of the future gen-

eration of nursing information systems. "*The information system described represents a new generation of systems design, predicated on a shift from a process-driven to a data-driven system ...*" ([23] p. VIII), with special attention to data-flow considerations. "*Essential characteristics of the system include: flexibility, connectivity, sufficient performance, assurance of security and confidentiality of data and an optimum human/computer interface*" ([23] p. 3). Importantly, evaluation of these systems' benefits is predicated on a multidimensional focus on support for information management. Thus, the system's adequacy for supporting clinical nursing practice and for investigating patient outcomes is paramount. The future generation system's guidelines were proposed with an eye to overcoming existing systems' deficits. Deficits that the new generation systems should overcome include: current systems do not support nurses' clinical decision-making; current systems lack integration and external connectivity with other databases; a uniform nursing language does not exist and is not supported; current user interfaces are cumbersome and not tailored to diverse, individual users; currently, nursing data input is restricted to structured language via checklist selections; retrieval of data to answer nursing questions is not currently available nor possible; archival data cannot be accessed; and, direct entry of data is hampered by cumbersome entry programs at the point of care.

Many reports of existing information systems for nursing continue to focus on the systems' capabilities for supporting nursing process and its documentation. Several bedside systems described in current literature focus on easier input of patient data; only a few describe the data that must be available for evaluating care and for determining patient outcomes. Hughes ([36] p. 139) describes bed-

side nursing systems that facilitate documentation of vital signs, fluid balance, admission history, medication and blood administration, and treatment and therapy administration with results and specimen collection; and, functionally based nursing systems that permit some version of order entry and results retrieval. Others continue to describe current nursing information systems from functional perspectives as patient management systems or nursing sub-systems that include: patient acuity or patient classification systems, care planning and documentation systems, quality assurance systems, order management/results reporting systems, inventory, discharge planning or evaluation systems ([37] p.15-16). While authors make no distinction between clinical care and nursing management systems, their examples illustrate the continuing predominance of systems that support nurses' performance of specific tasks from an organizational system's view of delivering patient care and managing that patient care.

These views of currently available task-oriented systems are evident in some of the papers accepted for presentation at an international conference on nursing informatics as they are focused on: order management, clinician order entry, and documentation [38]. Other papers, however, focus on database-oriented technologies i.e., constructing databases and using relational databases for supporting and improving care. Interestingly, one paper is focused on structuring nursing data for the computer-based patient record.

In contrast to the existing clinical care systems, a view toward future systems has become evident in nursing informatics publications. In a recent review of clinical nursing informatics, Ozbolt and Graves describe the challenges inherent in developing information systems that support clinicians' nursing practice [39]. Chal-

lenges they identify for nursing informatics clinical systems include: (1) identifying and defining nursing's language and structuring its data (2) understanding clinical judgment and how computer systems can facilitate, not replace it, and (3) discovering how well-designed systems can transform nursing practice. They also describe how external forces formerly had determined what data were included in systems, and how the policy shift to care effectiveness is influencing the current trend toward inclusion of data about patient problems, interventions and outcomes of care in systems that support nursing care.

Authors of papers for an international nursing informatics conference [38] attend to several of Ozbolt and Graves' challenges. The accepted papers describe: efforts to establish uniform keywords for use in systems; decision-support systems for trouble shooting pulmonary artery catheter waveforms; machine learning for developing an expert system to support nurses' assessment of preterm labor risk; the nature of nursing expertise; a computer-based approach to knowledge acquisition for expert system development; knowledge solicitation from expert nurse clinicians; an ambulatory care clinician's expert system; and the validation and implementation of an expert system in prenatal care [38].

As a result of the inclusion of specific types of clinical data in systems, Ozbolt and Graves note that it may soon be possible to assess the nature, effectiveness, quality, and value of nursing care. As a result, they say, nursing information may be able to be codified and included in the various discharge abstract databases used for health-care policy decisions, representing the next logical step in describing future nursing information systems.

Discussions about using clinical databases for policy research were held during a recent invitational confer-

ence on patient outcomes research [40]. Recommendations included a call for eliminating barriers to inclusion of clinical data that are useful for effectiveness research in automated systems. The recommendations did not, however, provide examples of specific data elements for inclusion. However, examples of clinical data elements that provide specific nursing information for effectiveness research as described by Ozbolt ([37] p. 413) were derived from the recommended Nursing Minimum Data Set [20]. The items included in the clinical system being tested include: nursing diagnosis, outcome of nursing diagnosis, nursing intervention, frequency of intervention, start and stop date and time of nursing intervention, principal nursing care unit, other nursing units, patient's average nursing acuity score, and average staffing level on unit during patient hospitalization.

Although not specifically identified as clinical systems' data items that are useful for effectiveness research, a Canadian conference on establishing a nursing minimum data set for Canadian health records was held to identify the elements and categories of the nursing minimum data set and to initiate a discussion of the elements and the common terms [41]. Although no conclusive statement on data items for inclusion in clinical systems resulted from this initial conference, its working groups were organized around: nursing diagnosis, nursing interventions, nursing intensity and outcomes, implying a potential focus on effectiveness research.

The NCNIP Task Force, described earlier in this paper [23], had a broader view about the scope of data that should be included in clinical information systems. In describing the types of data needed in systems for clinical care, they proposed a framework that identifies the necessary data as patient-specific, agency-specific and domain-specific ([23] p. 17). Patient-

specific data include all data captured and stored in the system about a particular patient, no matter what the source; agency-specific data includes all data pertinent to the agency in which care is given, and which is used for patient care; domain-specific data includes information and knowledge specific to the nursing discipline or to reference disciplines. Together, these data in clinical systems are thought to provide the types of information needed by nurses to support their clinical care efforts, as discovered by Corcoran-Perry and Graves [42].

### Nursing Informatics Research: State of the Science

Nursing informatics research also deserves consideration in any description of the current state of the science of nursing informatics. Because of the capability of research to help in setting directions for development of the informatics field by the nature of its discoveries about clinical nursing care and patients' responses to the care, it is important to describe its current focus. Nursing informatics research provides guidance to healthcare informatics professionals and system developers: about what nursing data to capture and in what form; about how data should be represented and synthesized within systems; about how data and information should be presented for use by practitioners in making decisions about providing care; about how data can be retrieved, manipulated and analyzed by researchers for discovering nursing knowledge; and, about evaluating clinical care support capabilities of systems.

However, caveats are in order when presupposing that the same databases that are useful for clinical care purposes can be also be used for nursing research purposes. As Zielstorff points out from a preliminary investigation:

*"Although automated clinical record systems have the potential for amassing a rich database for clinically focused research, several requirements must be met if this is to occur...The data must be valid and reliable and they must be structured in such a way that they can be analyzed...the data must be housed in a software environment that permits easy retrieval and manipulation"* ([43] p. 75). And, as she continues, *"clinicians have their own requirements for clinical record systems which may conflict with the objective of achieving a database useful for research"*. However, Zielstorff concludes, that perhaps with more advanced technologies, there will be ways to overcome such differences and have databases that can serve both clinicians' and researchers' needs. Fulfilling that hope is critical for nursing informatics.

An NIH convened priority expert panel on nursing informatics identified several issues in informatics that need investigation. Since these research priorities set the stage for future funding support, they are important to describe in this state of the science review [2]. The seven foci the panel identified include: using data, information and knowledge to deliver and manage patient care; defining and describing data and information for patient care; acquiring and delivering knowledge from and for patient care; investigating new technologies to create tools for patient care; applying patient care ergonomics to the patient-nurse-machine interactions; integrating systems for better patient care; and evaluating the effects of nursing informatics systems. Importantly, each of the expert panel report's chapters describes the state of the science for the above seven issues [2]. However, the research program goals that are derived from them provide cues about the types of informatics research that the National Institute of Nursing Research will support in the future.

For example, it is noted that *"informatics raises questions about how nurses use knowledge and information to make decisions, and the answers are important not only to the development of computer-based decision support systems, but also to the efficacy of everyday nursing practice"* ([2] p. 13). Thus the nursing informatics program goals of the National Center for Nursing Research (now the National Institute for Nursing Research (NINR) reflect an important dimension of this state of the science review.

The current NINR informatics research goals include ([2] p. 14.):

1. establish nursing language, including lexicons, classification systems, and taxonomies, as well as standards for nursing data;
2. develop methods to build databases of clinical information, including data, diagnoses, objectives, interventions, and outcomes, and management information. It is proposed to exploit the databases to discover new clinical knowledge, including descriptions of diagnoses relevant to nursing practice and to test relationships among diagnoses, objectives, interventions, and outcomes; also, to discover relationships between management variables and patient care;
3. determine how nurses use data, information, and knowledge to give patient care, and how care is affected by differing levels of expertise and by organizational factors and working conditions; and design information systems accordingly;
4. develop and test patient care decision-support systems and knowledge-delivery systems that are appropriate for nurses' needs, with consideration for expertise and organizational factors and working conditions;
5. develop prototypes and eventually working models of nurse workstations equipped with tools to provide to nurses all the information needed

for patient care, research and education, at the point of use, and linked to an integrated information system; and

6. develop and implement appropriate methods to evaluate nursing information systems and applications, particularly as to their effects on patient care.

Examples of research questions within each of the six program goals are provided in the publication as well ([2] p. 16-17). Heretofore funded nursing informatics research has included development of a lexicon and taxonomy of nursing interventions, development of an automated processing and retrieval system for nursing science literature, validation of a classification of nursing interventions, computer modeling of nursing practice in home care to predict patient resource utilization and, augmentation of traditional nursing care by providing information to persons with AIDS through an electronic network and bulletin board system ([2] p. 14). In summary, the document states that research specific to nursing needs and applications is needed to create, integrate, and evaluate information technologies; research is needed to develop and evaluate technological tools for patient care; integrate nursing with other components of hospital or agency information systems; integrate educational, research, and patient care features of nursing information systems; and develop methods for evaluating the effects of nursing information systems, especially on the processes and outcomes of care ([2] p. 15).

Several papers accepted for presentation at the Nursing Informatics-94 Conference [38] are reports of nursing informatics research that reflect the state of the science. For example, papers on evaluation aspects of systems include: impact evaluation of automated bedside documentation; measuring the effectiveness of critical care

systems; benefits of hospital information systems; evaluating information support for clinical practice guideline development; establishment of the research value of NMDSs; prevalence and relationships among elements of the NMDSs; and, evaluation of off-the-shelf patient classification systems. Additional nursing informatics research papers include: technology assessment of an integrated nursing information system in three Dutch hospitals; computer blueprint for nursing care planning: how effective was it; and, linkage of nursing minimum data set information and patient classification systems. Nursing management research topics include: approaches to predicting workload; nursing utilization review system for costing of nursing services by DRG; prospective and retrospective patient dependency systems; and using NMDS information for the allocation of budgets to nursing units.

Thus, from an overall perspective, nursing informatics research may include evaluation aspects of systems. Overall, however, the most important focus for informatics research seems to be, how do the data and information that are available from systems contribute to improvements in the quality of care provided. For informatics, clinicians, developers and researchers, the pragmatic questions that need consideration include: which types of systems will be most beneficial for improving nursing care delivery to its highest quality; what kinds of information are needed to advance systems to increasingly better levels of support for nurses' decisions about care; and what data are necessary for creating evaluative information that assists caregivers in improving patient outcomes.

Several final examples illustrate other nursing informatics concerns from the nursing informatics research community's perspectives. They provide a view of the critical issues of the

current state of the science of nursing informatics. They are:

1. Are decision support systems the best candidates for advancing nursing knowledge; or, are systems that provide tools for manipulating massive amounts of standardized data to answer vexing practice problems, better candidates;
2. Should systems routinely enhance practitioners' access to the broadest possible base of scientific literature, or should they merely provide abstracted information or consultation with other professional providers or researchers;
3. Are single-site, single-source, single-purpose evaluations of systems acceptable in determining their adequacy as information systems; and,
4. What criteria should be used for determining whether systems have been adequately evaluated; and, what information used for judging whether systems possess the capacity for supporting nursing care as well as the capability for advancing nursing knowledge;
5. Although workload-based staffing and scheduling systems have made substantial contributions factors associated with resource management and patient acuity should for these workload systems be expanded to include nursing knowledge so that variations in care and in patient outcomes can be explained.

In conclusion, the state of the science of nursing informatics is well-grounded in pragmatic issues related to clinical nursing information systems and relevant nursing informatics research concerns. Within 25 years the focus on nursing systems has shifted from process-oriented systems to data flow-oriented systems; and research is beginning to inform the nursing informatics arena. Concern about the data, information and knowledge of systems to support nursing care and



for knowledge development, seems to be shared by practitioners and researchers alike. A more comprehensive view of integrated systems and nursing data incorporated within them is the order of the day. However, the importance of these systems' comprehensiveness with respect to patient-specific, agency-specific and domain-specific data continues to be recognized and emphasized by clinicians. The importance of attention to policy and standards issues within a changing health-care environment is well noted by nursing informaticians, especially with respect to the demands that these changes will place on information systems for different types of data and potentially different uses and users of the information. Finally, the field of nursing informatics remains alive and is flourishing based on the evidence available from the papers submitted to its scientific meetings, especially the fifth international conference, Nursing Informatics-94 [38].

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