

JAMIA

Educational Curricula

Article ■

The Era of Patient Safety: Implications for Nursing Informatics Curricula

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■ *J Am Med Inform Assoc.* 2002; 9(Nov-Dec suppl):S120–S123. DOI 10.1197/jamia.M1242.

Introduction

In 1999, the Institute of Medicine (IOM) estimated that between 44,000 and 94,000 Americans die in hospitals each year due to medical error at a cost of over \$29 billion.¹ Only some of the “active” errors occur at the level of the frontline worker. Potentially more dangerous are the “latent” errors embedded in poorly designed, installed, or maintained systems; or in ineffective organization structure.² Nursing informatics has a crucial role to play in reducing latent errors because of its focus, in graduate curricula, on the design, implementation, and evaluation of clinical information systems.

The potential impact of informatics within the field of nursing has long been recognized.^{3–6} At the core of the nursing informatics curriculum is the design, development, implementation, and evaluation of clinical applications.⁷ Although implementation of a computerized patient record is proceeding slowly, 11% of healthcare facilities have complete systems and 32% have components of systems.⁸ These sys-

tems can play a crucial role in patient safety and error prevention, and nursing informatics is well positioned to influence their development and deployment. We have selected a group of papers that can be used within a nursing informatics curriculum to emphasize safety. The papers fall into four categories: clinical systems, human factors and communication, knowledge representation, and protecting confidentiality.

Emphasizing Safety in Nursing Informatics Curricula

Clinical Information Systems

Systems that support provider order entry and decision-making are the most prominent areas for system improvement and error reduction. It has been estimated that provider order entry can reduce serious medication error and adverse drug events (ADEs) by 55%.⁹ However, these systems can also promote user errors if not subjected to rigorous usability testing and evaluation. Goldstein et al. demonstrate how a clinical decision support systems (CDSS) can actually potentiate errors by (1) omitting relevant data, (2) increasing data overload, (3) providing guidelines

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inappropriate with a patient's profile, and (4) incorporating inaccuracies in program inputs or program logic. They propose a methodology to address unanticipated errors in guideline-based decision support systems that includes adequate training and regular system reporting as well as monitoring systems for adverse prescribing and administering practices.

Despite automated drug alert systems, adverse drug events (ADEs) comprise a significant portion of medical errors and contribute approximately \$2 billion in increased hospital costs.¹ In addition to the implementation of clinical decision support systems to prevent errors, other types of system automation are effective in detecting the actual occurrence and prevention of ADEs. Einbinder and Scully demonstrate that retrospective analysis using an electronic clinical data repository is an efficient and powerful method to evaluate rules and criteria to detect ADEs. Murff et al. devised an electronic screening tool for discharge summaries to detect, not only ADE's, but all adverse events (AEs). Their retrospective method identified adverse events in 31% of charts sampled, of which 52% were adverse drug events.

Defining, detecting and preventing adverse events (including adverse drug events) remains a challenge. Informatics programs that incorporate systems and information theory, software application development, and project design methodology, combined with extensive clinical experience in the development and evaluation of computerized systems, can be very influential in promoting systems that both detect and prevent adverse events. System evaluation, specifically quality assessment and improvement, is often neglected in informatics education and clinical applications. Collaborative teams of informatics educators, students, clinicians, and vendors have the combined knowledge and skills to develop quality improvement models that build safety in at all stages of the system development life cycle (SDLC).

Knowledge Representation

The development of ontological models has been consistently associated with knowledge representation in clinical informatics.^{10,11} The papers in this section describe ontological models for clinical processes that facilitate our detection and understanding of errors.

Advani et al. propose an approach for evaluating and consistently scoring clinician adherence to medical guidelines that employs an ontology. The model allows for the quality assessment of clinician actions

and patient outcomes. By creating a structure of guidelines that include both a guideline adherence algorithm and an intention recognition algorithm, the system allows for a "dynamic plan revision" that incorporates patient specific data and may result in a "plan substitution." This sophisticated approach to automated clinical guidelines attempts to address the issue of potential errors when clinical guidelines may not "match" a specific patient situation. The quality indicator language (QUIL) incorporates "annotated knowledge" to validly use point-of-care guidelines for quality assessment.

Stetson et al. propose developing an ontology that represents the intersection of medical errors, information needs, and communication space. Based on the premise that adverse events occur in a complex environment and involve information-seeking behavior, clinical communication, and information technology, the authors propose building an ontology that captures these three concepts. The proposed ontology will build on some of the existing semantic definitions in the UMLS Semantic Network in an attempt to re-use knowledge. This novel approach will further illuminate the factors that contribute to adverse events and provide a basis for informaticists to provide system solutions and promote future informatics research.

Finally, Nebeker et al. propose the development of a taxonomy of adverse drug events to counter the ambiguity of the current definitions and promote a prospective classification to facilitate future research. The authors categorize medical events by (1) drug and disease and (2) intent of person directing the drug use. In the first category, a distinction is made among the relation of disease, drug effect, and adverse event; in the second category, the authors differentiate between provider- and patient-directed therapy.

Human Factors and Communication

Much research related to human errors has been done in the fields of cognitive science and human factors engineering, although generally the focus has been on non-medical domains, such as aeronautics or nuclear reactors. Recently, more attention is being paid to the nursing arena.¹²⁻¹⁶ Zhang et al. provide a good entry for informatics students into the cognitive science/human factors literature by citing many of the important studies that address errors. A hierarchical model of medical errors is presented in which causes can be attributed to any (or all) of six levels: individuals; individual-technology interaction; dis-

tributed systems; organizational structures; institutional functions and national regulations. The remaining papers in this section analyze errors at the first four levels of the hierarchy.

Zhang et al. argue for a taxonomy of medical errors based on the cognitive mechanism(s) involved because problems attributable to different mechanisms will have different solutions. As a basis for developing such a taxonomy, students are introduced to classic papers such as Reason's definition of human errors² and Norman's cognitive theory of human action¹⁷ as well as a preliminary taxonomy of errors.¹⁸

The other papers can help students learn how informatics can be used to improve nursing work processes and communication, and thereby safety. Focusing on errors at the individual or individual-technology interaction levels of the system hierarchy of medical errors, Weinger and Slagle describe key concepts in human factors (workload and vigilance) that can affect clinicians' awareness of potentially dangerous conditions, as well as a methodology to evaluate clinicians' perceived workload, knowledge and decision processes, and detect "nonroutine" events that require clinical intervention. Although described for an anesthesia domain, the methods are equally applicable for nursing and medicine.

McKnight et al. and Moss et al. explore errors at the level of distributed systems or organizational structures, focusing on adverse events that result from communication problems. McKnight et al. introduce students to Coiera's concept of "common ground."¹⁹ In addition, the authors describe research identifying specific information needs and communication difficulties of physicians and nurses that might contribute to errors. Although both groups identified gaps in information access that could result in poor clinical outcomes, the gaps were quite different, suggesting the need for very different informatics solutions. Moss et al. describe a data collection tool to analyze the communication involved in the coordination of patient flow by an operating room charge nurse. The paper also describes the evaluation of a specific communication artifact, the Operating Room Board, which might be the focus of an informatics solution to communication errors.

Protecting Confidentiality

Increasingly, clinical and genomic data collected as part of routine patient care are being made available to the research community as a way to support evi-

denced-based practice, conduct epidemiological studies, or develop predictive models. For researchers, using available data is very cost-effective and for some types of studies is the only realistic way to collect the volume of data needed.²⁰⁻²² However, there is a safety issue in the use of large data sets—protecting patients' privacy.^{23,24} The two papers in this section identify, from an informatics perspective, the challenges in balancing patient privacy concerns with research needs.

Dreiseitl et al. identify a potential problem in the algorithms used for ambiguating data, a technique to assure privacy protection. Given sufficient computational power for a brute-force solution, "disambiguation" can ultimately result in retrieving information about specific individuals. Thus, anonymization techniques facilitate the release of large data sets for research, but may be insufficient for assuring patient privacy. Anonymization techniques also have implications for subsequent data use. One way to protect patient privacy is to eliminate any and all data elements that might be used as identifiers. Taken to the extreme, this may render the data set useless. However, if less restrictive algorithms are applied, patient privacy may be at risk. Ohno-Machudo, Vinterbo and Dreiseitl investigate the degree to which anonymization degrades the quality of the data set.

Implications for Nursing Informatics Curricula

Creating a safe patient environment is a very complex issue that will require the combined knowledge and skill of clinical informaticists, informatics faculty, researchers, and system designers. This milieu cannot be developed without vigorous informatics education informed by the novel approaches described in this selection of papers. Further implications for nursing informatics education include: (1) the standardization and defining of terms and taxonomies that represent knowledge of the domain and can be linked to a "patient-centered" ontology that also supports other disciplines; (2) student projects that require informatics students and developers to work collaboratively to improve current systems, particularly clinical decision support systems to prevent and detect adverse errors; (3) project development content that prepares students to conduct rigorous usability testing, provide appropriate system training, and adopt quality improvement models to evaluate the effectiveness and accuracy of automated systems; and (4) emphasis

on communication, information needs, and complex clinical environmental issues as they relate to systems engineering and implementation. Finally, informatics faculty should work together with system designers to expand the development of collaborative, safety-related student informatics projects in a "real-time" laboratory environment.

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