Structured analysis: Methodology for developing a model for defining nursing information system requirements

Including nurses in decisions to purchase or design information systems is an increasingly common phenomenon. Without previous informatics experience, nurses may need help defining specific requirements for information systems that will assist in managing and administering nursing care. The Model for Defining Nursing Information System Requirements was developed to serve as a guiding framework for deriving nursing information system (NIS) requirements. Structured analysis techniques were used to develop the model. The model was tested by surveying 75 registered nurses who had made decisions about NISs. Subjects supported the model's completeness and usefulness for defining NIS requirements.

Carole A. Gassert, PhD, RN
Assistant Professor
School of Nursing
University of Maryland at Baltimore
Baltimore, Maryland

USING INFORMATION technology has become an accepted part of health care as agencies are forced to process tremendous amounts of information more efficiently and more cost-effectively to survive.[1] A vital part of health care, nursing has also seen increased application of information technology in its practice. More than half of the hospitals with 200 or more beds have installed some type of computerized nursing information system.[2] A nursing information system (NIS) is a computerized system that collects, stores, processes, retrieves, displays, and communicates information that nurses need for managing and administering nursing care.[3]

Nursing has not been included in the selection, planning, or development of information systems,[4] and once systems are installed nursing is constrained to adapt to systems that are often incompatible with its information needs. Mowry and Korpman[1] indicate that 80% of existing information systems are cost-recovery rather than patient-centered

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systems. If an agency is to install a computerized system that assists its nurses in managing and administering nursing care, the nurses must identify their specific information system requirements. Nurses are increasingly being included on information system committees to provide input about their needs. They may, however, have limited experience with information technology[5-7] and little or no formalized education in informatics. Only recently has a nursing program been available that prepares graduate nurses in the field of nursing informatics.[8] Most nurses have needed to rely on the nursing informatics literature for guidance in identifying nursing information needs and system requirements.

Nursing informatics literature is primarily future oriented, prescriptive, or descriptive and not research based.[9,10] Many articles list guidelines for selecting nursing systems,[4-7,11-19] but no systematic, graphic model for identifying nursing information system requirements was found in the literature. Such a model could help nurses identify their information system requirements prior to system selection and installation. Describing, from the user's point of view, the way a nursing information system is expected to perform should increase usefulness of nursing information systems.

MODEL DESCRIPTION

The purpose of this descriptive study was to develop a graphic model that would provide a guiding framework for deriving requirements for NISs and to test the completeness and usefulness of the model. Techniques for developing the graphic model included structured analysis and content validation. The Model for Defining Nursing Information System Requirements (MDNISR) is pentagonally shaped and has five elements that are linked together in sequential order (Fig 1). Within each model element data are received as inputs, undergo specific processing, are considered in relation to identified influences, and result in unique information or outputs for that element. Collectively the five model element outputs, which are nursing information functions, nursing information processing requirements, nursing system outputs, nursing data requirements, and nursing system benefits, specify an agency's requirements for a nursing information system.

Once developed, the MDNISR was tested with a sample of 75 registered nurses from around the United States who had participated in planning, designing, selecting, enhancing, or evaluating NISs. A self-administered questionnaire, emanating from the model's content, was used to test the clarity, completeness, and usefulness of the model. Although model testing is an important part of development, this article will focus on methodologies used in constructing the model and only briefly summarize the results of testing.

STRUCTURED ANALYSIS

One of the primary methodologies used to develop the MDNISR was structured analysis (SA). Initially suggested by Ross and Schoman[20] as a means of describing a computer system, and later by Borich and Jamelka[21] as a vehicle for program evaluation, SA is an organized and patterned approach for graphically documenting what someone thinks about a topic. A topic of

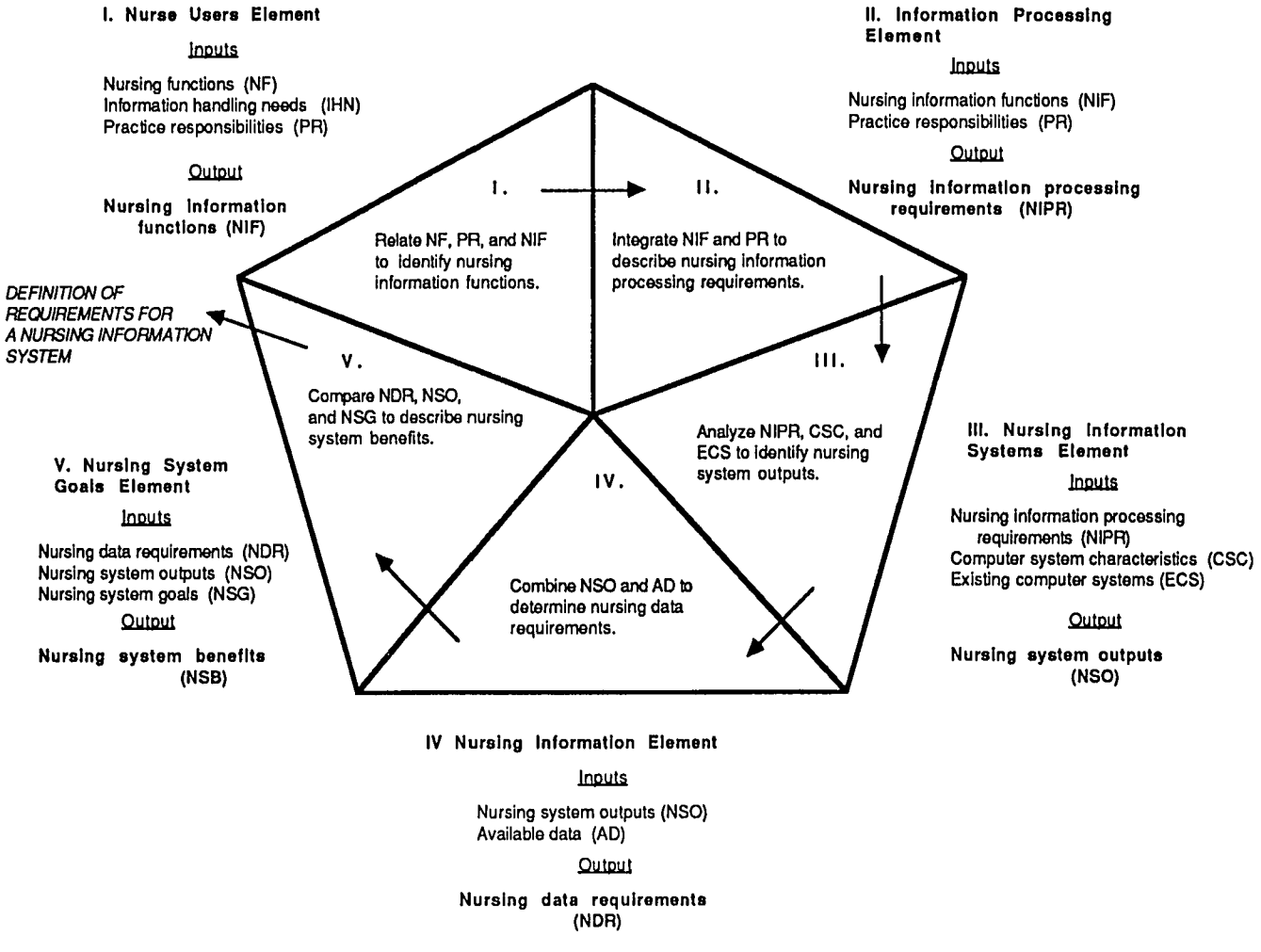

Fig 1. Model for defining nursing information requirements.

interest is conceptually broken down into subtopics and represented graphically as a set of diagrams. Each diagram in the set is composed of boxes, arrows, natural language names, and symbolic notations. Boxes within each diagram represent parts of the whole being analyzed. Arrows in the diagram indicate relationships that occur between various parts of the whole. Specific SA language symbols are used to label diagrams.[22]

A set of diagrams is arranged in levels demonstrating the graphic model's modular configuration, hierarchic structure, and means-ends continuum.[20,21] Modularity is demonstrated by presenting a series of diagrams. Each diagram explains only a portion of the topic of interest. Hierarchy is demonstrated by presenting the diagrams as descending levels of subtopics. Within the hierarchic ordering of diagrams, lower level subtopics depend on higher level subtopics for their definition. A means-end continuum is demonstrated when an entity can be the end or output of one event at the same time that it is the means or input for another event. Thus sequential relationships among processes within the graphic model are established.

There are specific guidelines for performing SA. A box is used to show a transaction, defined as an activity, process, or event. Each transaction within the topic is activated by inputs, outputs, constraints, and mechanisms. Inputs, defined as things a transaction uses, enter the box from the left. Outputs, defined as things produced by or resulting from the combination of inputs and constraints acting on the transaction, exit from the right of the box. Constraints, defined as any things that modify or influence a transaction and its output, are diagrammed as arrows pressing down on the box from above it. Constraints can be either negative or positive influences. Mechanisms are means of activating a transaction and are diagrammed as arrows pressing upward on the box. Designating inputs, constraints, processes, and outputs for each transaction in a graphic model shows how the transactions are interrelated.

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Before developing the MDNISR, it was necessary to examine the process of selecting an information system for a health care agency (see Fig 2). Using SA, six clusters of transactions needed to select the system were identified at Level 2. One of these transactions is to decide about an information system for nursing services. At Level 3, the five activities that nursing must perform before deciding about an information system are activate nursing informatics committee, determine the definition of requirements for an NIS, identify vendors to present information about their systems, utilize demonstration sites, and compare definition of requirements and available nursing information systems. Level 4 is the MDNISR, the mechanism for defining NIS requirements.

MODEL DEVELOPMENT PROCESS

In developing the MDNISR, the following four major steps were used: (1) establishing

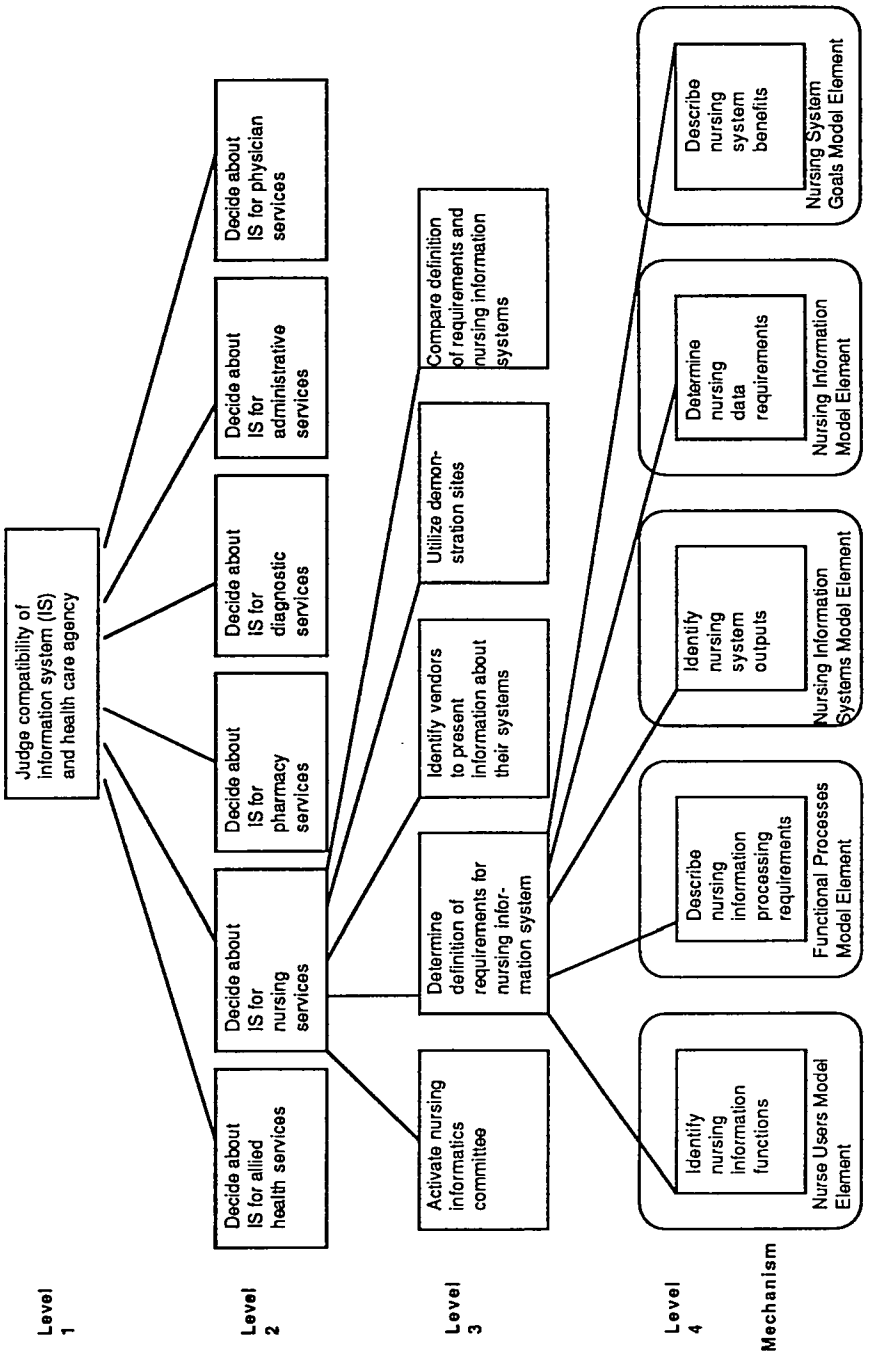

Fig 2. Analysis of topic: selecting an information system for a health care agency.

a conceptual framework, (2) using SA to identify subelements, (3) validating the model content, and (4) drawing the graphic model.

Conceptual framework

Schwirian[9] proposed a pyramid-shaped model as a guiding framework for nursing informatics research that would promote an accumulation of knowledge in the field. Schwirian's triangular base of informatics activity is concerned with information, users, and computer systems. Interaction among the base elements reaches toward the goal of the informatics activity. These four concepts guided the review of nursing informatics literature and served as the conceptual framework for the MDNISR.

Literature about information systems, information processing needs and problems, and guidelines for developing or selecting systems relative to the four concepts was included in the review. Nursing informatics literature supported the four elements described by Schwirian as being important to consider when deciding about NISs.

Identifying model elements

Once the four model elements were substantiated by literature review, they were analyzed using structured analysis techniques to identify subelements. The model elements were conceptually broken down several times to logically explain the inputs, processes, outputs, and constraints needed to define NIS requirements. Terminology used to label subelements was either derived directly from the literature or synthesized by the investigator from discussions that appear in the literature reviewed. The resulting subelements suggested the need for a fifth model element concerning information processing to be added to the model. As a result, the MDNISR includes five model elements: nurse users, information processing, nursing information systems, nursing information, and nursing system goals.

Validation of content

Content validity for the MDNISR was established by analyzing published guidelines for selecting NISs[4–7,11–19] and comparing them to the five elements and associated subelements in the proposed model. A matrix was constructed to facilitate the comparison. Several sets of published guidelines incorporate all five model elements. Zielstorff,[19] involved in developing inpatient and outpatient systems in Massachusetts, posed five general questions for determining needed information about systems. Her questions relate to subelements within all five of the model elements. Cook,[12] while discussing El Camino's system, also posed questions that should elicit essential information about systems. Her questions parallel subelements within all of the model elements. Romano and McNeely[18] and Romano et al[17] explained their process of system development at National Institutes of Health Clinical Center. These authors suggested activities that include subelements from all five of the model elements. Rieder and Norton[16] discussed their process of developing the TRIMIS information system used in the military. Their steps for nursing system development likewise include subelements from all five of the model elements.

The matrix further indicates that Ball and Hannah,[11] Drazen,[13] Hoffman,[5] McAlindon et al,[14] Powell,[6] and Weaver and Johnson[7] have also included subelements from each of the model elements in their guidelines. The remaining author, McCarthy,[15] included subelements of four elements, information processing, nursing information systems, nursing information, and nursing system goals, in her guidelines for deciding about systems. As the guidelines proposed by these experts were examined and compared to the MDNISR, it appeared that content validity for the proposed model was established.

Graphic model

Structured analysis produced a graphic model of the process of selecting an information system for a health care agency that was very long and detailed and written in specific SA language. It appeared to the investigator that such a lengthy document could not be satisfactorily circulated for testing. The last phase of model development, therefore, was to abstract essential information from the complete document to include as the MDNISR. The result is the pentagonally shaped model in Fig 1.

The extracted model was then submitted to a panel of six nationally recognized experts in nursing informatics to establish further content validity. Each of the experts had experience with selecting, evaluating, enhancing, or developing an NIS. Panel members had a master's or doctoral level of education and had spent a mean of 7.2 years in their current positions. Five experts indicated their primary responsibilities were in information technology and one expert indicated her primary role was that of professor. All experts have published in the field of nursing informatics.

Panel members were asked to judge the content validity of the model by completing the questionnaire developed for the study. The questionnaire was constructed from the model using an item form/item frame technique that allowed the same information to be asked about each of the five model element outputs. Panel members indicated whether they felt each model element's output was important to include when deciding about NISs and whether they had used the particular subelement in their practice of deciding about NISs. As a panel, the experts considered all five model element outputs to be essential when deciding about NISs. The mean scores for "essential" for each model element output were greater than the minimally acceptable 7.5, with a possible score of 0 to 10 on a visual analog scale (VAS). In addition, the experts had used each model element's output in deciding about NISs in their practice. Mean scores for "extent to which you used the model element output" were greater than the minimally acceptable 7.5, with a possible score of 0 to 10 on a second VAS. These results supported the content validity of the model elements and selected subelements included in the model.

When asked to indicate other data that needed to be considered in deciding about NISs, the panel of experts listed items that had been included in the more detailed graphic model. For this reason the model distributed to subjects for testing was expanded to include more of the subelements identified by the structured analysis process.

The panel offered helpful comments about the model and questionnaire. As a result of their suggestions, titles for two model elements were clarified, two subelements were

renamed, elements were reordered, definitions were clarified, questionnaire items were expanded, directions were added to the questionnaire, and additional items were added to the questionnaire.

MODEL TESTING

The revised model for defining NIS requirements was further tested for completeness and usefulness through a pilot study of 11 nurses, seven of whom had made decisions about NISs and 4 of whom had not made decisions about NISs. Content validity, face validity, and test-retest reliability was established for the questionnaire. In the pilot study scores of decision makers and nondecision makers were compared to establish construct validity but failed to show any significant differences.

Upon completing the pilot study, questionnaire booklets, which included the graphic model, were mailed to a purposive sample of 148 registered nurses who had been identified as decision makers for NISs in hospitals throughout the United States. A total of 75 subjects (50.6%) completed and returned usable questionnaires. Subjects indicated on a 10 centimeter VAS whether specific model element outputs should be considered when deciding about NISs. Scores of 7.5 or greater indicate the output should be considered. Participants also denoted how much they actually used those indicators on a second 10 centimeter VAS. Scores of 7.5 or higher meant decision makers used that indicator a substantial amount in deciding about NISs. To validate understanding of the definitions used, participants were also asked to list three examples of each model element output. Listing 66% of examples correctly indicated that subjects understood the definitions given for model element outputs.

Study findings supported the clarity of model element outputs. Subjects were able to use the definitions of model element outputs to list more than 66% of the examples correctly for each of the five model element outputs. The clarity of model element outputs was further substantiated by the finding that most subjects were able to understand the clinical and administrative examples of defining NIS requirements given in the booklet.

Completeness of MDNISR was supported by three analyses. First, subjects were asked what additional data they considered necessary in deciding about NISs. Seven subjects indicated two new data items that had not been included in the larger model. The two items are constraints and were added to existing model elements. No new model elements could be inferred from data suggested. Second, subjects were asked whether anything was missing from the model. A majority of subjects did not respond to the question. Those who responded did not suggest that new data needed to be added to the model. In a third analysis, subjects indicated with mean scores of greater than 8.6 that all of the model element outputs are essential to the model.

Usefulness of MDNISR was also supported by study findings. Subjects' scores of 8.1 or higher on the 10 centimeter VAS indicated they had actually used the five model element outputs in deciding about NISs.

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Nurses are now included on information system committees and have assumed responsibility for defining requirements for

NISs installed in their agencies. Resources are needed to help less experienced nurses successfully identify what they need in NISs. The Model for Defining Nursing Information System Requirements may be of assistance in preparing a requirements document. The MDNISR identifies five specific pieces of information that need to be included in the requirements document. When initially tested with nurses who had made decisions about NISs, the model was supported as being complete and useful. Subjects also felt definitions used in the model were clear. Further testing of the model is needed to substantiate its usefulness. It would be helpful to use the model to prepare a requirements document for a specific agency.

In this study structured analysis was used as a methodology for model construction. SA allows any topics to be analyzed with a formalized structure. A topic can be broken into smaller and smaller subtopics until the concepts and their relationships are understood. The SA methodology might be helpful in developing other models needed within nursing informatics.

The MDNISR used Schwirian's nursing informatics research model[9] for its conceptual framework, and findings support its use for nursing informatics research. Only one other study has been found that used Schwirian's framework. Webber[23] used the four elements to describe information systems in Canada. These two studies used Schwirian's framework in different ways. Together, however, they demonstrate that the suggested theoretic approach can guide nursing informatics research.

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