

A Delphi Study to Determine Informatics Competencies for Nurses at Four Levels of Practice

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- **Background:** Despite its obvious need, a current, research-based list of informatics competencies for nurses is not available.
- **Objective:** To produce a research-based master list of informatics competencies for nurses and differentiate these competencies by level of nursing practice.
- **Methods:** After a comprehensive literature review and item consolidation, an expert panel defined initial competencies. Subsequently, a three round Delphi study was conducted to validate the items. Participants were expert informatics nurse specialists in the United States of America.
- **Results:** Of the initial 305 competencies proposed, 281 competencies achieved an 80% or greater agreement for both importance as a competency and appropriateness for the correct practice level. Five competencies were rejected. Six competencies were considered valid competencies but the appropriate level of practice could not be agreed upon. Thirteen competencies did not reach any consensus after the three Delphi rounds.
- **Discussion:** The Delphi study had a high rate of participation, demonstrating the great level of interest and need for a list of informatics competencies for nurses. Out of the initial 305 competencies, only 24 items were not validated. Respondents commented during each round about whether computer skills should be considered informatics competencies. The authors propose that computer skills, while not high level, are one set of tools within the larger category of informatics competencies. This sample of experts did not deem programming skills as necessary for informatics nurses. This research study is an initial effort to fill the void of valid and reliable informatics competencies. It is the first study to span four levels of nurses, create competencies for both entry-level and experienced informatics nurse specialists, and examine the categories of computer skills, informatics knowledge and informatics skills.
- **Key Words:** informatics competencies • nursing informatics competencies

The message is clear from healthcare leaders and organizations. Healthcare professionals need to have informatics knowledge and skills (AACN 1997, 1998; Gassert, 1998; IMIA, 1999; Pew, 1998). These can range from how to use a clinical application or knowledge about basic technology terms to more advanced concepts surrounding nursing structured languages or evaluating the impact of a clinical system on practice. Because of the need to manage data volume and complexity, nurses need informatics skills and knowledge for survival in any arena.

As early as 1988, the National League for Nursing published categories of informatics competencies for nurses. These were developed by a workgroup from the International Medical Informatics Association or IMIA (Peterson & Gerdin-Jelger, 1988; Grobe, 1989). More recently, the Pew Commission affirmed that communication and information technologies were 1 of 21 competencies required by all health professionals (Pew, 1998). The American Medical Informatics Association (AMIA) focused the entire 1999 AMIA Spring Congress on the informatics education of health professionals (Staggars, Gassert & Skiba, 2000). Within nursing, the American Association of Colleges of Nursing (American Association of Colleges of Nursing, 1998) and the National Advisory Council on Nursing Education and Practice (Gassert, 1998) released general guidelines about nurses' education in healthcare and information technologies. More recently, IMIA approved broad guidelines and core informatics concepts for information technology (IT) users and specialists in health informatics (International

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Medical Informatics Association, 1999). Hebert (2000) stated, however, that to date informatics has belonged to the specialists. Instead, all nurses would benefit from technical, conceptual and applied skills in nursing informatics (NI).

In addition to guidelines, authors published specific material about informatics knowledge and skills needed by nurses. Unfortunately, authors did not agree about the competencies required for nurses, they did not publish competencies for advanced informatics nurse specialists, and the lists are not current. Thus, a recent, research-based, and validated list of informatics competencies is not available to guide curricular development in formal education programs. Likewise, employers have no validated informatics competencies to apply to nurses' performance in the work setting.

The purpose of this study was to produce a research-based master list of informatics competencies for nurses and to differentiate these competencies by level of nursing practice. A master list is a comprehensive set of skills and knowledge that nurses exhibit across sub-specialties within the field. It does not necessarily mean that every nurse at a given level would be competent in all items at that level. For example, an informatics nurse specialist would not be expected to be competent in all 174 identified and validated competencies.

With the creation and validation of these competencies, this study is the first one to span four levels of nurses, create informatics competencies for both entry-level and experienced informatics nurse specialists, and examine the categories of computer skills, informatics knowledge and informatics skills.

Review of the Literature

The following terms in combination with the words "skills, competency, literacy or knowledge" were used to search databases for relevant literature: (a) computer, (b) information technology, (c) information systems, and (d) informatics. In addition to numerous terms, the authors used several databases to locate literature, including MEDLINE, CINAHL, PubMed, and HealthSTAR. The resulting literature is organized into major themes: (a) categories of competencies, (b) perceptions about competencies, and (c) past lists of competencies.

Categories of Competencies

Authors do not agree about categories of NI competencies. Some emphasize computer literacy skills (Walker & Walker, 1994; 1995; Lewis & Watson, 1997); while others speak to information literacy (Verhey, 1999), a combination of informatics knowledge and computer skills (Armstrong, 1986; Bryson, 1991); patient-centered information (Travis & Flatley Brennan, 1998); or methods for integrating competencies into nursing curricula (Riley, 1996; Vanderbeek & Beery, 1998).

Perceptions About Competencies

Verhey (1999) evaluated students' perceptions pre and post computer literacy training finding that perceptions about knowledge and skills improved after training. Austin (1999) on the other hand, surveyed nurse educators about their perceptions of instructor competence in 60 computer literacy skills as well as the integration of these skills into baccalaureate education. Austin discovered that 21 of the 60 skills were performed at least "well" by 50% of the respondents; however, only 3 of the 60 skills were integrated into teaching by at least 50% of the educators surveyed.

Carter and Axford (1993) studied the computer learning needs of 96 clinical nurses with either beginning or expert computer knowledge in Australia. They only agreed that one area of competency was essential, the one addressing practical knowledge and skills for computer operations.

Lists of Competencies

Using a two-round Delphi technique, Armstrong (1986) surveyed a panel of nurse educators about present and future needs for computer competence in nursing practice and teaching. The resulting list included psychomotor, cognitive and affective competencies in the areas of: (a) knowledge about computer technology, (b) the nurse's role and issues with computers, and (c) computerized documentation development.

Later, Bryson (1991) developed a comprehensive list of competencies from nursing educators' perceptions about the amount and kinds of computer training needed in baccalaureate programs. This list was organized by seven computer literacy domains, including knowledge, attitudes, and computer skills. The list included: (a) basic computer hardware and software, (b) computer operations, and (c) understanding the concepts of programming (not programming courses). Stagers (1994) measured computer experience across levels of nurses with a 43-item tool assessing: (a) computer knowledge and computer uses, (b) hospital information knowledge and uses (c) nursing informatics specialist role activities, and (d) the number of informatics/computer courses completed. For informatics students' self-assessment, Gassert and MacDowell (1995) developed a list of computer literacy, systems analysis, and informatics role skills.

Observations About Studies

A majority of these cited works were based in academic programs and examined either nursing faculty or students' perceptions about informatics needs or competencies within educational programs (Stagers, Gassert & Curran, 2001). Carter and Axford's (1993) study is unique in that the sample is bedside clinical nurses; otherwise, samples were students and faculty.

The studies dealt more often with entry-level competencies (computer skills) than those needed by either experienced nurses or nursing informatics specialists. The knowledge and skills informatics nurse specialists require,

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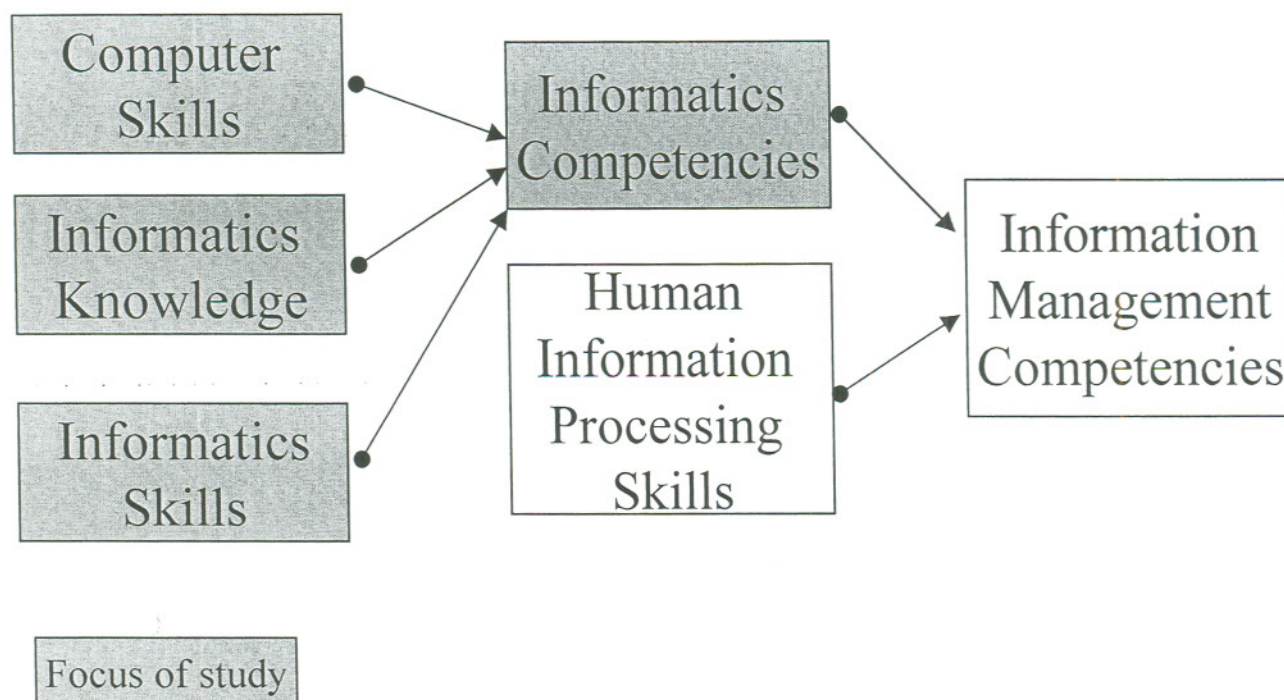


FIGURE 1. Information Management Framework.

e.g., systems analysis, or system selection techniques, are outlined in only two publications (Staggers, 1994; Gassert & McDowell, 1995). However, the knowledge and skills required by highly experienced and/or educated informatics nurses (e.g., great depth of expertise), were absent. Except for Staggers, authors did not address specific competencies across several levels of nurses.

The available publications built less upon each other than was anticipated (Staggers, et al., 2001). For example, the validated competencies from Armstrong (1986) and Bryson (1991) have been available for many years, but their adoption into curricula is not yet evident. More important, these informatics competencies are seemingly absent from competency determinations within work settings. In summary, then, there is a critical need for a current, research-based and specific list of informatics competencies for nurses at various levels of practice.

Framework for the Study

The authors developed a conceptual framework to guide the study (Figure 1). The terms and concepts in the framework were derived from a synthesis of nursing and informatics sources. The skills and knowledge concepts were basic concepts mentioned in literature about competencies in nursing; these two concepts are foundational for competency development. The informatics terms evolved from categorizing the 1,159 database items extracted from the literature. To be consistent with the competency literature, the authors chose the term computer skills to represent basic functioning with technology. This term corresponds to others used in the literature i.e., computer literacy or information technology skills. Computer skills is defined in this study as the profi-

ciency in the use of computer hardware and software. Computer skills, while not high level, are considered a component of informatics competencies.

Other elements in the framework include informatics knowledge and skills, a set of competencies beyond just learning how to manipulate computer technology. As the initial list of items were examined, they inductively separated into the categories of informatics skills and knowledge. Informatics knowledge is the theoretical and conceptual basis for the specialty, while informatics skills are the use of methods, tools and techniques particular to informatics. For example, informatics skills include techniques and tools in systems analysis and project management. Informatics knowledge includes familiarity with nursing taxonomies and reasons for systems slowness. The larger construct of information management includes skills in cognitive information processing capabilities. However, this study focuses upon informatics competencies and the antecedent categories represented in the conceptual framework.

Methods

To validate the competency statements and level of performance, the study included five steps: (a) competencies were extracted from the literature, (b) unique competencies were listed, (c) competencies were leveled and expanded by an expert panel, (d) pilot test was administered, and (e) three Delphi rounds were conducted. The initial competency development in steps (a) through (c) is described elsewhere (Staggers, et al., 2001). The levels of nurses are defined in Table 1. After step (c), the list of competencies included 304 statements in 39 categories (Table 2).

TABLE 1. Definitions for Levels of Nurses

Beginning nurses (Level 1) have fundamental information management and computer technology skills and use existing information systems and available information to manage their practice.

Experienced nurses (Level 2) have proficiency in their domain of interest (e.g., public health, education, administration). These nurses are highly skilled in using information management and computer technology skills to support their major area of practice. They see relationships among data elements, and make judgments based on trends and patterns within these data. Experienced nurses use current information systems but collaborate with the informatics nurse specialist to suggest system improvements.

Informatics specialists (Level 3) are registered nurses prepared at least at the baccalaureate level who possess additional knowledge and skills specific to information management and computer technology. They focus on information needs for the practice of nursing, which includes education, administration, research and clinical practice. Informatics specialists' practices are built on the integration and application of information science, computer science and nursing science. In their practice, informatics specialists use the tools of critical thinking, process skills, data management skills (includes identifying, acquiring, preserving, retrieving, aggregating, analyzing, and transmitting data), systems development life cycle, and computer skills.

Informatics innovators (Level 4) are educationally prepared to conduct informatics research and to generate informatics theory. These nurses lead the advancement of informatics practice and research because they have a vision of what is possible, and a keen sense of timing to make things happen. Innovators function with an ongoing healthy skepticism of existing data management practices and are creative in developing solutions. Innovators possess a sophisticated level of understanding and skills in information management and computer technology. They understand the interdependence of systems, disciplines, and outcomes, and can finesse situations to maximize outcomes.

Pilot Test

A pilot test was conducted to identify any issues with the questionnaire or the individual items. The goals were to assess: (a) the average amount of time required to complete the questionnaire, (b) clarity of items, (c) clarity of instructions, and (d) adequacy of the format. Content issues included the importance of the item as an informatics competency for nurses and whether the item was correctly placed within levels were also examined. Three experts, well known as pioneers in the NI field, participated in the pilot.

Respondents reported that between 45 to 60 minutes were needed to complete the questionnaire. There were no suggestions for improving the presentation format and no items were added or deleted from the list. Seven items needed clarification, and these items were reworded for the Delphi rounds. Participants recommended that one item be split into two statements. Consequently, the item "develops implementation plans and marketing materials" was split into

"develops implementation plans" and "develops marketing materials." Participants mentioned that some items were role specific for administrators or educators. However, the goal was to develop a master list of competencies, so no qualifications were placed on the competencies that were role specific by the expert panel and the items were retained.

Delphi Study

A Delphi study approach was used to achieve consensus about a master list of informatics competencies required for nurses with differing levels of expertise in the United States. Three rounds were needed to reach consensus. To be consistent with the expert panel work used to establish the initial competencies, a threshold of 80% consensus was used. A purposive sampling technique was used to identify participants who had the following criteria: (a) registered nurses with a master's degree or higher in nursing, (b) five years

TABLE 2. Number of Subcategories in Each Level of Practice

Category	Beginning Level 1	Experienced Level 2	Specialist Level 3	Innovator Level 4
Computer skills	9	8	6	2
Informatics knowledge	4	5	7	2
Informatics skills	0	2	15	6

TABLE 3. Number of Participants Contacted and Items Sent by Round

	Round 1 Dec 1999	Round 2 July 2000	Round 3 Feb 2001
Number of participants	79	72	70
Item importance	305	88	33
Appropriate level	305	11	9

experience in NI practice, and (c) visibility within the specialty through presentations, publications, or an officer in informatics organizations. Expert panel members suggested potential study subjects and supplied their e-mail addresses.

The final "Informatics Competencies for Nurses" questionnaire for Round 1 of the Delphi study was 19 pages long and included 305 items in 39 subcategories within the 3 broad categories of computer skills, informatics knowledge, and informatics skills. Because of the length of the questionnaire, 110 potential subjects were contacted by e-mail to determine their willingness to participate. In December 1999, the questionnaire was mailed to the 82 nursing informatics specialists who agreed to participate in the study. After survey receipt, three subjects did not meet the requirements for participation. Of 79 eligible subjects, 72 (91%) returned usable responses.

In July 2000, 72 respondents received Round 2 surveys. Only the 88 items that failed to meet 80% consensus were included in the 9-page questionnaire. The questionnaire contained three sections of data for each item: (a) the total participant response (in percentages) by response category for every item on Round 1, (b) that participant's individual responses for each item, and (c) space for the individual's Round 2 responses. Both item importance and

appropriate level data were given for all items within each category. Seventy subjects (97%) responded to Round 2.

The third and final round of surveys was sent in February 2001. The data presentation format was the same as Round 2. Because the Round 3 questionnaire contained only 33 items and was 6 pages long, the 70 subjects were given an option of receiving either an electronic or hardcopy version of the questionnaire. Most (65) subjects preferred an electronic copy. Sixty-five (93%) respondents returned Round 3 surveys; all but one returned the survey electronically. An overall retention rate of 87% from the beginning to the end of the Delphi study reflects the interest and enthusiasm of the Delphi study participants in identifying and differentiating informatics competencies for nursing (Table 3).

Results of the Delphi Study

By the end of Round 3, 281 items (92%) of the original 305 competencies were accepted as valid competencies for *both the importance of the item and the appropriateness of the level* (Table 3). Table 4 lists the percent agreement by level of practitioner while Table 5 depicts the number of competencies validated by level of practice. The master list of validated competencies is available at <http://www.nurs.utah.edu/informatics/competencies.htm>.

TABLE 4. Percent Agreement on Items by Level of Practitioner and Delphi Round

	Round 1	Round 2 ^a	Round 3 ^a	Cumulative % After Round 3
Usable surveys	72	70	65	
Item importance				
Beginner (%)	56	63	14	86
Experienced (%)	46	63	100	100
Specialist (%)	75	59	63	96
Innovator (%)	90	100	n/a	100
Appropriate level				
Beginner (%)	95	50	0	98
Experienced (%)	97	0	100	100
Specialist (%)	97	0	40	98
Innovator (%)	92	34	0	95
Overall total				
Importance (%)	71	63	39	93
Level (%)	96	18	34	97

^aPercentages represent the % agreement within the round and are not cumulative across rounds.

TABLE 5. Number of Competencies Approved by Level of Nurse

Level of Nurse	Initial	Final
Beginner	43	37
Experienced	35	32
Specialist	187	174
Innovator	40	38
Total	305	281

Of the 24 competencies not validated, only 5 were rejected (Table 6), 2 competencies from the experienced nurse level and 3 from the informatics specialist level of practice. The competency "writes an original computer program and modifies it" was rejected early at Round 1. The other 4 competencies did not reach an 80% agreement to discard them until Round 3.

Six competencies were determined to be valid competencies but no agreement was reached about their practice level. Only 1 of these 6 competencies achieved the 80% threshold of agreement that it was at the wrong level, but subsequently, respondents could not reach agreement on a correct level (Table 7). No competencies changed levels of practice as a result of the Delphi study.

Thirteen items did not reach agreement as valid competencies. Interestingly, these fell into 2 distinct practice levels: the beginning nurse and the informatics specialist. All of these beginning nurse competencies came from the computer skills category. For the informatics specialist level, which clearly had the largest number of competencies by level of practice, items that did not achieve consensus came from all three major categories.

Only the experienced nurse level achieved a 100% consensus on listed competencies by the end of Round 3 for importance and level. The nurse innovator level reached 100% agreement for item importance but 2 items ("teaches informatics competencies required for specific role functions for the practicing nurse, the nurse administrator" and "evaluates applications supporting clinical care (including decision support), education, administration, and/or research") did not achieve agreement about appropriate practice level.

On all three rounds, participants were given the opportunity to write in comments or additional competencies. The research team a priori set a criterion that 10% of the participants had to introduce the new competency or comment on the same competency for those items to be included in the next round. Fifty-four percent of the participants (39 individuals) made comments on Round 1. Comments involved 85 items (28% of the total items).

Only 7 items had 3 or more comments and none met the minimum criteria of 7 comments. One item received 5 comments. However, this item had a printing error when sent out. Of the 7 items, 1 item, "Has the ability to integrate different applications or programs" was in the computer skills category and the other 6 were in the informatics skills category.

TABLE 6. Rejected Competencies

Experienced Nurse

- Uses applications for diagnostic coding
- Uses desktop publishing

Nurse Informatics Specialist

- Applies computer-assisted software engineering (CASE) tools
- Manages central facilities to enable data sharing
- Writes an original computer program and modifies it

Other items with comments had only 1 or 2 comments each. In general, comments varied from "don't think this is a NI competency" or "only if in an administrative role," to recommending wording changes, especially verb changes, (e.g., circled "manage" and changed to "analyze").

Twenty-one (30%) participants made comments on round 2. Only 2 items had 3 or more comments. About 20 comments on this round occurred at the bottom of pages and were not related to specific competencies. Examples include "remain concerned that there is no advanced nursing content here," "many of the elements identified here are appropriate for selected jobs but are not core competencies for all nurses at level 3," and "believe all of these are computer literacy and not informatics."

There were 25 comments from 16 respondents (25%) on round 3. General comments included:

1. Matching the appropriate level of research activity and the informatics level. Specifically, that level 3 nurses should apply and use research but that level 4 nurses should generate research (3 comments).
2. The perspective each individual used to respond to the survey (i.e., several individuals felt that responses changed as their jobs changed) (3 comments).
3. The informatics specialist nurses "modifying" software, which should be left to programmers (2 comments).
4. Basic computer skills such as spreadsheets and presentation software being a pre-nursing (and pre-college) requirement (2 comments).
5. The competency "evaluates network capacity" being too technical, but that the knowledge component should be included as a competency (2 comments).
6. A number of respondents commented favorably about receiving the survey via e-mail.

Discussion

The high response rates of 91% in Round 1, 97% in Round 2 and 93% in Round 3 demonstrated the great level of interest and need for a comprehensive list of informatics competencies. Despite the 19-pages in the initial questionnaire, a majority of participants completed the form, and the study had a high response rate overall.

The vast majority (92%) of competencies and their associated levels were validated. Out of 305 competencies and their associated levels, only 24 items were not vali-

TABLE 7. Valid Competencies With an Undetermined Level of Practice**Valid Competency With Consensus That Item Is at The Wrong Level**

- Uses authoring tools to develop CAI for students, nurses and/or patients (originally at the experienced nurse level; 77% placed this competency at the informatics specialist level)

Valid Competencies With No Consensus About Level

- Recognizes computerized diagnosis equipment (e.g., CAT scan, MRI, digital imaging)
- Conducts research to examine effects of computer technology in nursing (originally at the informatics specialist level)
- Conducts research in informatics (originally at the informatics specialist level)
- Teaches informatics competencies required for specific role functions for the practicing nurse, the nurse administrator (originally at the nurse innovator level)
- Evaluates applications supporting clinical care (including decision support), education, administration and/or research (originally at the nurse innovator level).

dated for both importance and level. Five additional items were deemed important competencies but consensus could not be reached about an appropriate level.

Respondents commented during each round about whether computer skills should be considered informatics competencies. One respondent even crossed out all the items related to computer skills during Round 1 and said that none of these skills should be considered part of informatics competencies. In the literature, the terms computer skills and computer literacy are ill defined and often used interchangeably. As per the information management framework used in this study, computer skills are one set of tools within the larger category of informatics competencies that are ultimately needed to manage information.

Participants clearly did not view computer programming as a required competency for informatics nurse specialists. The competency directly speaking to programming (i.e., "writes an original computer program and modifies it") was rejected in Round 1. Similar competencies such as "identifies the more common programming languages in use today," did not reach consensus after 3 rounds. Comments were made that these competencies applied to "programmers" and not informatics nurse specialists.

The results of this Delphi study created a master list of informatics competencies for nurses at four levels of practice. In the past, Armstrong (1986), Bryson (1991), and Stagers (1994) used research techniques to create lists of competencies for nurses. Armstrong studied the "computer competence" needed for nursing practice and teaching in the early-1980s, while Bryson created a list of skills needed for computer training in baccalaureate programs. Stagers (1994) created a list of skills and knowledge for nurses in the early 1990s. Despite numerous discussions about the need for informatics competencies, no research-based competencies were created since the early 1990s. Therefore, this study answers the need for valid informatics competencies, and it is the first study to span four levels of nurses, create competencies for both entry-level and experienced informatics nurse specialists, and examine the categories of computer skills, informatics knowledge and informatics skills.

The study results complement the work performed by the International Medical Informatics Association (1999).

The IMIA provided broad guidelines such as knowledge about general characteristics of health information systems. This study outlines the specifics of those characteristics.

There are limitations to this work. While the expert panel added competencies to the nurse innovator level, the Delphi participants added no new competencies. Thus, the current list may not be exhaustive. The research team set a threshold of 10% for the addition of a new competency. Future research should state the required threshold on the survey as well as provide a summarized overview of comments made regardless of the frequency of the comment.

Since the creation and validation of competencies is a time-consuming process, additional competencies should be added to the master list. New competencies should also be added to the master list as the specialty evolves and as more nurses develop expertise in a specific subspecialty within informatics (e.g., database design).

Competencies were validated only by informatics nurses and not by beginning and experienced nurses. The research team specifically chose only informatics specialist or innovator level nurses because non-informatics nurses may not know the competencies required at their level of practice. However, one participant in Round 2 commented that he/she "remained concerned that there is no advanced nursing content." Interestingly, the competency "uses applications for diagnostic coding" was eliminated from the experienced nurse level on Round 3. Perhaps if advanced practice nurses (i.e., master's prepared nurse practitioners, had participated) they would have retained the competency above item and generated additional items for review.

This study provides a current, research-based list of informatics competencies. Few competencies were eliminated or failed to meet consensus and the resulting list spans many topics, showing the content diversity of informatics.

The last research-based work in this area was in the early 1990s, did not include advanced informatics content, and it did not include four levels of nurses. Follow up to this specific research should define the *core competencies* for nurses by level of practice and job type and to create valid and reliable tools to evaluate informatics competency levels. Other research could concentrate on explicating the full set of competencies needed within the framework cre-

ated for this study (i.e., adding the competencies for human information processing to informatics competencies). Then, the full suite of competencies would be explained for nurses' management of information. ▀

Accepted for publication August 18, 2002.

The authors thank the expert panel members and the experts participating as pilot subjects: Barbara Carty, EdD, RN; Sue Grobe, PhD, RN, FAAN; Mary McAlindon, PhD, RN; Ramona Nelson, PhD, RN; Rita Snyder-Halpern, PhD, RN, C; and Cheryl B. Thompson, PhD, RN, and especially Melody Rydgren, MS, RN, whose participation in this work and obvious dedication to nursing informatics was remarkable.

The views expressed in this article are solely those of the authors and not necessarily those of the Health Resources and Services Administration, Department of Health and Human Services.

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