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Nursing Informatics Competency Assessment for the Nurse Leader

Instrument Refinement, Validation, and Psychometric Analysis

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OBJECTIVE: The aim of this article is to refine and validate a new instrument, Nursing Informatics Competency Assessment for the Nurse Leader (NL).
BACKGROUND: Because health information technology rapidly advances, the NL requires greater levels of informatics knowledge.
METHODS: Item reduction and psychometric analysis methodology
RESULTS: A total of 357 national NLs completed the survey. Exploratory factor analysis resulted in a final 6-factor solution that contained 26 items: (1) strategic implementation management, (2) advanced information management and education, (3) executive planning, (4) ethical and legal concepts, (5) information systems concepts, and (6) requirements and system selection. Cronbach's α were .96, .91, .90, .83, .92, .81, respectively.
CONCLUSION: We established a valid and reliable nursing informatics competency assessment instrument with sufficient specificity to guide NLs to recognize the competencies required in their role, create solutions to address potential gaps, and enhance delivery of patient care.

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Healthcare leadership faces an increasingly complex environment. New reimbursement paradigms must focus on patient outcomes, an expanding list of patient-related data including socioeconomic as well as environmental and genetic information, new health information technology (HIT) that hopes to improve usability, safety, and interoperability; and the communication demands of patient-centered care and patent empowerment. Participation by nursing as a full partner in meeting the challenges of HIT requires new skills and responsibilities for nurse leaders (NLs). New informatics knowledge is indicated to become a full partner in HIT adaption, implementation, design, and innovation. Efforts to close knowledge gaps require a validated set of informatics competencies relevant to NLs and an instrument to identify individual gaps in knowledge. Subsequently, future education curricula for NLs should be focused on the specific needs of nursing leadership based on validated gaps in knowledge related to HIT.

To address this gap, we conducted a 2-year, multimethod study to define, develop, and validate a nursing informatics (NI) competency self-assessment instrument specific to the needs of NLs to evaluate their levels of NI competencies and target learning and professional development opportunities. We followed the 8-step scale development process by DeVellis.[1] summarized in Table 1. For each step, we identify the process step and the method(s) used: (1) clarify the intended concepts to measure, (2) generate an item pool, (3) determine the format for measurement, (4) have the initial item pool reviewed by experts, (5) consider inclusion of validated items, (6) administer items to a development sample, (7) evaluate the items (item performance, factor analysis, and alpha), and (8) optimize scale length. We separated the 8 steps into 2 phases: competency identification and

Table 1. *Eight-Step Scale Development Process[1] and the Corresponding Methodologies Used in Developing the Nursing Informatics Competency Assessment—Nurse Leader (NICA-NL) Survey Instrument[2]*

Development Phase	Instrument Development Process Steps	Method(s) Used
Competency identification	1. Clarify the intended concepts to measure 2. Generate an item pool 3. Determine the format for measurement	Environmental scan of indexed research databases using key terms to identify initial list of competencies for evaluation
	4. Have the initial item pool reviewed by experts	Delphi study in 3 rounds for content and face validity using a survey instrument and content validity index
Factor analysis	5. Consider inclusion of validated items 6. Administer items to a development sample	Multivoting and survey instrument
	7. Evaluate the items 8. Optimize scale length	Exploratory factor analysis for scale optimization and factor identification

factor analysis. Our first article, *Nursing Informatics Competency Assessment for the Nurse Leader (NICA-NL): The Delphi Study*,[2] describes the methods and results of the competency identification phase and identifies 74 competency items specific to the NL. The work described in this first article is largely based on previous work by Westra and Delaney.[3] This second article builds on the results of the competency identification phase and details the development of a final validated instrument to measure informatics competencies specific to the NL, NICA-NL. When taken together, the 2 articles provide a detailed description of our methods and the resulting NICA-NL instrument.

Methods

The methodology described here continues our previous work, identifying a set of informatics competencies specific to the NL. Here, we report the factor analysis phase from step 5 to step 8. All study procedures were approved by Partners Healthcare System's institutional review board.

Step 5: Consider Inclusion of Validated Items

In our previous research, 74 competency items were identified as part of the competency identification phase of this work.[2] As part of the factor analysis phase, each item was re-evaluated for inclusion in the sample instrument. Using an established consensus-building multivoting method, like items were combined to reduce the length of the potential NICA-NL and categorized into potential competency factors.[2] The multivoting method involved a series of votes that facilitate consensus on the prioritization and inclusion of lists. The 4 authors, who each have extensive and diverse informatics and nursing knowledge, conducted 3 multivoting cycles to reach a consensus on the initial informatics competency instrument.

Step 6: Survey Distribution

The proposed informatics competency instrument was constructed using a 5-point Likert scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; and 5, strongly agree). We also added an option, *don't understand*, in case any question was not clear. The proposed instrument was distributed by sending a survey via e-mail to national NLs at the following organizations for their completion: (1) Organization of Nurse Leaders (ONL) (Massachusetts, Rhode Island, New Hampshire, and Connecticut), including ONL board of directors and committee governance structure; (2) Alliance for Nursing Informatics Governing Board; (3) Association of California Nurse Leaders; (4) California Institute for Nursing and Health Care; (5) Catholic Health; (6) Cerner Corporation; (7) Dignity Health; (8) Hospital Corporation of America Healthcare; (9) Healthcare Information and Management Systems Society NI Symposium; (10) Kaiser Permanente; (11) Texas Health Resources; and (12) University of California Los Angeles Health System. In addition to the informatics competency instrument, demographic questions were asked as part of the survey to determine participants' eligibility and background, such as age, gender, education, position, and working experience. No specific exclusion criteria were applied beyond the participant's position as a NL, as indicated in their survey response.

Steps 7 to 8: Item Reduction and Psychometric Analysis

To establish the quality of a new survey instrument, exploratory factor analysis is commonly used. Exploratory factor analysis is a statistical method used to reduce variables and discover the underlining structure of data, for example, to understand how the data correlate. We used exploratory factor analysis to validate, optimize, and explore the psychometric properties of the proposed NICA-NL. The procedures included the following: (1) determine the number of factors needed for the exploratory factor analysis.[5-7] The number of factors represents the number of aspects that exist in a survey instrument; (2) select an extraction and rotation (orthogonal or oblique) method to assess the stability of factor solution across a different number of factors. The rotation methods are the assumption of

whether the factors are correlated (oblique) or uncorrelated (orthogonal) with each other; (3) repeat item reductions until the final solution is reached based upon item factor loadings. This iterative step ensures that the structure of the survey instrument is stable; and (4) further eliminate items affecting Cronbach's α reliabilities.[8,9] This final step further enhances and examines the reliability of the survey instrument.

Several methods were used to determine the number of factors retained for exploratory factor analysis. The most common and used method is the eigenvalues-greater-than-one rule. However, because of the problems and disadvantages of using such a rule, other methods are recommended, including parallel analysis (PA),[10] Velicer's minimum average partial,[5,11] and model fit indices.[12] Among those, PA is the most recommended method,[6,7,13,14] which is based on generating random variables to determine the number of factors. To provide a better estimation, we used PA, eigenvalues, and model fit indices to determine the number of factors needed. We selected principal axis factoring (PAF) with oblique rotation (promax) as the extraction method; because in social and behavioral science, we usually expect some correlation among factors. With orthogonal (varimax) rotation, it may lose information if factors correlate.[8]

In summary, we examined multiple solutions with various numbers of factors using PAF with promax rotation. For every solution, we repeated item reductions based on item loadings (.32 or higher on 2 or more factors or less than half the difference of factor loading with other factors)[8,9] until the final solution was reached. Once we determined the final factor structure, we further inspected the Cronbach's α reliabilities.

Results

Step 5: Consider Inclusion of Validated Items

Considering the usability of a survey instrument, 74 items in a survey instrument is lengthy and may not receive reliable responses.[15,16] With the goal of providing an approximately 25-item instrument, a pool of 45 items was ideal to proceed onto survey distribution to collect data for item reduction with factor analysis. The multivoting method[4] reduced the 74 items to a 45-item instrument with 12 categories (Table 2). The categories in Table 2 were not mutually exclusive; therefore, the sum is greater than 45 items. For example, 1 item, "ability to lobby and negotiate requirements for HIT," was categorized as belonging to executive leadership, requirements and system selection, and strategic decision-making.

Step 6: Survey Distribution

In total, we received 539 responses from NLs, 357 of which were valid with less than 20% missing values.

Table 2. Categories Included After the Multivoting Method

Categories	Number of items[a]
Ethical/legal concepts	2
Executive leadership	7
Financial management	2
Implementation management	7
Information management	3
Information system concepts	8
Instructional design	1
Interdisciplinary collaboration	3
On-going system evaluation	1
Requirements and system selection	3
Strategic decision-making	6
Technical knowledge	6

[a]Categories are not mutually exclusive; therefore, the sum is greater than the 45 items that were categorized.

Answers as *don't understand* were treated as missing data. Among the 357 responses, each item has less than 4% missing data. Table 3 reports the demographics of our participants. Participants' age ranges from 21 to 76 years, with an average of more than 26 years of working experience. Most have a master's degree and are nurse managers, directors, or chief nursing officers (CNOs).

Steps 7 to 8: Item Reduction and Psychometric Analysis

Among the valid 357 responses with less than 20% of the values missing, 216 responses had no missing values. Because complete responses with no missing values are required to perform exploratory factor analysis, the 216 complete responses represented only half of our sample and were not considered adequate for our analysis. To preserve the 357 valid responses, expectation maximization was used[17-19] to impute the missing values. Expectation maximization has been suggested and used in imputing missing values for this purpose.[18,20,21]

While determining the number of factors, we found that PA suggested 6 factors, eigenvalues of more than 1 suggested 5 factors, and model fit indices suggested 5 to 7 factors. After initial review, we decided to assess factor solutions with 5 or 6 factors in detail. We carefully assessed the items loaded into each factor. Our NI and practice experience helped us determine that based on the interpretation and meaningfulness of each factor a 6-factor solution best described the NI competency for NLs.

The final 6-factor solution contained 26 items in the following 6 categories: (1) strategic implementation management, 10 items; (2) advanced information management and education, 5 items; (3) executive planning, 4 items; (4) ethical and legal concepts, 2 items; (5) information systems concepts, 3 items; and (6)

Table 3. *Participant Demographics*

	N = 357		
Age, y		Professional position, n (%)	
Range	21-76	Clinical nurse	6 (1.7)
Mean (SD)	51.85 (9.54)	Clinical nurse leader	22 (6.2)
Sex, n (%)		Clinical nursing specialist	19 (5.3)
Male	30 (8.4)	Nurse manager	74 (20.7)
Female	325 (91)	Director	103 (28.9)
Missing data	2 (0.6)	Chief nursing officer	38 (10.6)
Ethnicity, n (%)		Other	95 (26.6)
White/Caucasian	304 (85.2)	EHR functionalities, n (%)	
Black/African American	12 (3.4)	CPOE	294 (82.4)
Hispanic/Latino(a)	13 (3.6)	Clinical decision support	220 (61.6)
Asian/Pacific Islander	17 (4.8)	Laboratory	302 (84.6)
Native American	2 (0.6)	Radiology (PCAS)	292 (81.8)
Prefer not to answer	2 (0.6)	Pharmacy	301 (84.3)
Other	1 (0.3)	Health information exchange capability	215 (60.2)
Education (all levels), n (%)		Physician documentation	295 (82.6)
BS/BA	151 (42.3)	Nursing documentation	311 (87.1)
MS or MSN	213 (59.7)	Current EHR, y	
MBA	31 (8.7)	Range	0-45 years
MPH	5 (1.4)	Mean (SD)	7.34 (6.6) years
RN	123 (34.5)	EHR developer, n (%)	
DNP	24 (6.7)	Homegrown	20 (5.6)
PhD	28 (7.8)	Commercial EHR	225 (63)
Current practice setting, n (%)		Combined	58 (16.2)
Academic institution/medical school	31 (8.7)	Not sure	19 (5.3)
Academic medical center	93 (26.1)	Missing	35 (9.8)
Critical access hospital	6 (1.7)	HIMSS EMR adoption model, n (%)	
Community hospital	149 (41.7)	Stage 1	8 (2.2)
Integrated health system	42 (11.8)	Stage 2	19 (5.3)
Private practice	3 (0.8)	Stage 3	10 (2.8)
Public health	2 (0.6)	Stage 4	12 (3.4)
Other	30 (8.4)	Stage 5	49 (13.7)
Missing data	1 (0.3)	Stage 6	66 (18.5)
Years in position, mean (SD)		Stage 7	72 (20.2)
Years in current position	6.16 (6.46)	Not sure	83 (23.2)
Years working experience (total)	27.7 (10.58)	Missing	38 (10.6)
		Current state of EHR (multiselect), n (%)	
		Have EHR	324 (90.8)
		In the process of having EHR	111 (31.1)

Abbreviations: EHR, electronic health record; HIMSS, Healthcare Information and Management Systems Society; PCAS, picture archiving and communication system.

requirements and system selection, 2 items. Table 4 shows the factor correlation matrix.

We also reported the final 26 items in Table 5 with their factor loadings. We also conducted reliability testing to examine its internal consistency. The Cronbach's α were .96, .91, .90, .83, .92, .81, respectively.

Qualitative Analysis

During the survey, we allowed participants to provide feedback. Among the 539 responses, we received 50 comments. As we expected, even with a shortened instrument of 45 items, some respondents still thought it was too long. The resulting 26 items from our findings

Table 4. *Factor Correlation Matrix*

Factor	1	2	3	4	5	6
1. Strategic implementation management	1.000	.763	.707	.489	.713	.778
2. Advanced information management and education		1.000	.708	.549	.654	.723
3. Executive planning			1.000	.525	.616	.655
4. Ethical and legal concepts				1.000	.346	.503
5. Information systems concepts					1.000	.621
6. Requirements and system selection						1.000

Table 5. Nursing Informatics Competency Assessment for the Nurse Leader

Factor	Item	Factor loadings					
Strategic implementation management (α = .961)	1. Change management for HIT	1.004					
	2. Ability to manage the effect of change because of HIT implementation	0.973					
	3. Understanding of methods for evaluation of HIT implementation and use	0.846					
	4. Ability to champion the collection, analysis, and trending of nursing data in nonnursing-dominated HIT discussions	0.838					
	5. Communicating a system and nursing vision about the benefits of HIT	0.825					
	6. Ability to evaluate, contribute, and revise project scope, objectives, and resources	0.749					
	7. Recognition of value of clinicians' involvement in all appropriate phases of HIT	0.727					
	8. Conceptual understanding of the importance of integrating nursing data elements in HIT systems	0.659					
	9. The ability to understand regulations and transitions in policies because they relate to HIT	0.510					
	10. A conceptual understanding of nursing intervention documentation using HIT, it's effect of care delivery, nursing productivity, and secondary use of information	0.398					
Advanced information management and education (α = .911)	11. Conceptual understanding of data quality issues for HIT		0.824				
	12. Searching information retrieval systems		0.804				
	13. Avoidance of potential negative impacts of HIT		0.765				
	14. Understanding of methods for HIT education		0.659				
	15. Ability to understand technological trends, issues, and new HIT developments because they apply to nursing		0.529				
Executive planning (α = .897)	16. Ability to define (in collaboration with the IT department) TCO containment strategies and hidden costs on HIT implementation (ie, education, system maintenance, upgrade support staffing requirements, and physical plant change)			0.996			
	17. Ability to define (in collaboration with the IT department) TCO specifically when it relates to the HIT-related cost of staff education and re-education related to upgrades and staff turnover			0.771			
	18. Ability to function in a strategic capacity for HIT and not at a functional or recommender role			0.656			
	19. Ability to collaborate with CMO peers related to HIT and needs of nurses and physicians			0.418			
Ethical and legal concepts (α = .829)	20. Understanding of patients' rights related to HIT and computerized patient data				0.849		
	21. Understanding of ethical principles for collection, maintenance, use, and dissemination of data and information related to HIT				0.823		
Information systems concepts (α = .917)	22. Ability to conceptually understand how to define, design (create a schematic), and implement an HIT solution to achieve overarching nursing workflows					0.682	
	23. Ability to standardize nursing process and automate workflow related to HIT					0.650	
	24. Ability to understand HIT "work-arounds" and the consequences of human-computer interface interactions					0.645	
Requirements and system selection (α = .810)	25. Ability to integrate patient care processes and nursing administrative functions in HIT system requirements						0.844
	26. Ability to assure that nursing values/requirements are represented in HIT selection and evaluation						0.736

Abbreviations: HIT, health information technology; IT, information technology; TCO, total cost of ownership.

provided a more satisfying and practical length for NLs to assess their NI competency. Other respondents addressed difficult language and terminology that was used in some of the survey questions and some additional questions that needed to include consideration of electronic health record (EHR) capabilities. Their suggestions were not included in current NICA-NL, but will be considered in our future direction to advance NICA-NL.

- "[NICA-NL] really reveals how deficient I am in this area, need much more education on this."
- "I do not speak this language."
- "The questions are conflicting to an individual's personal experience, knowledge, and capability versus what is implemented within an organized healthcare system regardless of this."
- "I recently relocated to this role where there is a 'mostly' implemented [EHR vendor] system, which leaves me feeling less certain than I was before. I spent 14 years of my career in 1 health system where I was a bedside nurse, quality manager, clinical performance director, and CNO. That was an [other EHR vendor] organization, and I was highly integrated in go live and clinical informatics, data mining, reevaluation of discrete data, and much more. In that setting, I was very comfortable with HIT and ongoing changes. We were attesting to MU6 [Meaningful Use 6] when I left. Some of my answers are reflective of my new setting, EHR and system."

NI Education and Training

Some participants commented that education and training focused on NI are necessary to understand some of the specific terms used, particularly when a NL has no informatics training or not in an informatics-related role. Continuous education focused on informatics is needed for working nurses and NLs to effectively engage with content and discussions that relate to the informatics domain.

- "Conceptually and theorywise, I understand quite a bit; but resourcewise, have not been able to fully implement my role as an informatics nurse."
- "I am currently in a master's of science in nursing program taking informatics. I really hope that you can implement informatics into the undergraduate level and also work to give older nurses an opportunity to learn this."
- "I have only been in my role as a clinical nurse manager for 2 months. I have not been exposed to many of these concepts as a staff nurse. I believe, with further education and training, I can become competent in area related to nursing informatics."

Self-Assessment Versus EHR Assessment

Some feedback provided from participants related to assessing the EHR, given that EHRs often have some limited capabilities that serve as a barrier to work; however, limitations of the EHR are not related to a nurse's level of competency. Yet, limited system functionalities or resources do affect the role of an informatics nurse and the ability to implement standard practices or competencies.

- "May want to consider participants' understanding of HIT issues versus actually implementing them"
- "The biggest challenge has been to make sure that the system meets the actual needs. Huge amounts of customization were necessary for our [EHR vendor], product and because of this, the roll out was very slow and continues to pose challenges around effective documentation and our ability to retrieve aggregate information despite having an electronic record."

Discussion

Maintenance, Ongoing Engagement With Stakeholders, and Use of NI Competency Assessment Instrument in the Field

The past 2 decades have resulted in tremendous technological advances and altered day-to-day relationship with technology. As a result, a number of competencies and their categories required revisions to maintain relevance to the current state of technology, broadly, and the landscape of HIT, specifically. We found that ranking priorities at the category level and revising for relevance was a useful approach. This approach could be leveraged as an efficient procedure for frequent review of the proposed competencies to identify gaps in the context of the current landscape of HIT. Periodic detailed curation of each competency will be required moving forward and should be implemented as processes and expectations align with the knowledge management life cycle.

Foundational instrument development is advanced by applying a system life-cycle approach for competency implementation and maintenance and ongoing value- and outcome-based evaluations that are relevant to stakeholders and their organizations. The mission, vision, purpose, and measurable short- and long-term goals of NI competency tool implementation must be identified because the instrument is used and tested in the field. It is important that these concepts are applied to define a business case for healthcare organizations to adapt tools that support informatics competency attainment for NLs.

Implications for NLs and Executives

This research provides a foundation and focus for specific informatics and technology competencies

required by today's CNO and NL. Until now, informatics and technology competencies were not adequately defined for these roles nor had the specificity required to develop curriculum or continuing education programming. The ability to define specific factors (ie, HIT requirements, concepts, and management; strategic planning; executive leadership; financial management; and ethical/legal concepts) can be easily translated into curriculum and educational content. This research also provides a survey instrument can be used to evaluate the success of such initiatives. The validation of these competencies also provides an opportunity to collaborate with information technology and finance experts in an effort to become "multilingual." In this way, today's NL will be prepared to bring, and not delegate, digital competencies to interprofessional initiatives because they create optimal and supportive environments of care.

Conclusion

Health information technology is a rapidly evolving field and is changing the way nursing care is being delivered. This research focuses on the skills required by the NL and recognizes that there are specific NI competencies required in this role. In addition, this research helps to specify exact competencies and create a focus. This study established a valid and reliable NI competency assessment instrument with sufficient specificity for NLs. These findings will allow NLs to recognize NI competencies required in their role, help create solutions to address potential gaps, and enhance patient care delivery.

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