Evaluation of UNIS: Urological Nursing Information Systems

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Unis is a nurse expert system prototype specifically designed to assist nurses caring for elderly, incontinent patients residing in nursing homes. Two studies measuring the performance level of UNIS were implemented. In the first study, results of sessions with UNIS on case studies of elderly, incontinent patients were compared to sessions with nurse experts. The relevance of questions, value of recommendations and overall performance were rated by an evaluation panel. In the second study, UNIS was implemented on two nursing units in a nursing home. The number of wet occurrences of patients residing on units where UNIS was consulted by nurses was compared to the number of wet occurrences of patients residing on units where UNIS was not consulted by nurses. The knowledge of urinary incontinence of nurses who consulted UNIS and those who did not consult UNIS were also compared. The results indicate that when judged by an evaluation panel, the relevance of the questions and value of the recommendations generated by UNIS were not rated significantly different than ratings assigned to nurse experts consulting on the same case studies. There was a significant difference between assigned ratings for overall performance; $F_{.01}$ (4,16) =10.4. UNIS scored the highest on four out of five case studies. In the second study, the number of wet occurrences of patients residing on units where nurses consulted UNIS decreased significantly; $F_{.01}$ (2,9)=34.67. The knowledge of urinary incontinence also improved significantly when nurses' consulted UNIS; $F_{.001}$ (2,157)= 19.46. The methods and results of these two studies are presented.

Introduction

Urinary incontinence affects all age groups and is particularly common in the elderly. Close to one half of all nursing home residents suffer from urinary incontinence [1]. At the 1988 Consensus Conference on Urinary Incontinence, one of the greatest problems identified in the field was the lack of health professionals with a working knowledge of urinary incontinence [2]. This is precisely the type of problem at which expert system technology is directed [3].

Description of UNIS: The design component of UNIS included the user definition, knowledge base, inference engine and user interface. The user of UNIS was defined as any member of the nursing personnel caring for elderly patients who were known to be incontinent of urine and residing in a nursing home. The knowledge base of UNIS was defined as a collection of "rules" which reflected the knowledge of nurse experts in the domain of urinary incontinence. Of the several algorithms which could be used by the inference mechanism, forward and backward chaining procedures were implemented. This combination of forward and backward chaining was especially useful because there were often no single recommendations to be proven or disproven. UNIS's user interface was designed to mimic the consultations performed by nurse experts with nursing personnel caring for elderly, incontinent patients in long-term care facilities. Specifically, the interviewing process which takes place between the nurse expert and a nurse was mirrored so that a similar process could take place between UNIS and a nurse during a computer session. UNIS was developed using NEXPERT OBJECT by Neuron Data, Inc., located in Palo Alto, California.

Study One: Performance Level of UNIS

Participants: In the first study, there were two groups of participants; the nurse experts and the nurse evaluators (who were also experts). Four nurse experts were recruited. A nurse expert was defined as a registered nurse who was: 1) known to have published in the field of urinary incontinence; 2) recommended by at least one other nurse expert and 3) known to have participated in urinary incontinence research projects. Two of the nurse experts were nurse practitioners and two were clinical specialists. Three out of four nurse experts held masters degrees in nursing.

Six nurse evaluators were recruited using the same criteria for the nurse experts described above. Five of the nurse evaluators were nurse practitioners and one was a clinical specialist. All of the evaluators held masters degrees in nursing and one held a doctoral degree.

0195-4210/91/$5.00

All participants were unfamiliar with UNIS and blinded to the purpose of the study.

Data Collection: Face-to-face, question-and-answer sessions were scheduled with each of the four nurse experts. Each nurse expert was presented with five case studies which were randomly selected from a pool of fifty case studies designed by a content specialist. The nurse expert received a brief oral presentation of the patient by the interviewer and was instructed to begin asking questions to obtain pertinent information about the patient's case. When the nurse expert felt she had obtained sufficient information, they were asked to state their recommendations for the patient. The results of all sessions (questions asked, information given about the patient and recommendations stated) were taped recorded. The same five cases were used to perform sessions with UNIS.

The results of the sessions with the nurse experts and UNIS were transcribed into a standardized format and labeled with anonymous codes. Data were mailed to the six nurse evaluators who were instructed to read each of the case studies and rate the relevance of the questions, value of the recommendations and the overall performance of the subjects (four nurse experts and UNIS).

Data Analysis: Each question could have a total score across the ratings assigned by the six evaluators of 6 to 42 (where 1=irrelevant and 7=extremely relevant x 6 evaluators). The mean scores were calculated by summarizing the total score for every question on each case study and dividing the number of questions asked on each case study.

Similar methods were used to calculate the ratings obtained on all the recommendations asked by UNIS and the four nurse experts. Each recommendation could have a total score across the ratings assigned by the six evaluators of 0 to 60 (where 0=not valuable and 10=extremely valuable x 6 evaluators).

Each expert (UNIS and the four nurse experts) could have an accumulative overall performance score ranging from 5 to 15 (range of scores from 1 to 3 x 5 case studies).

One-Way Repeated Measure Analysis of Variance Tests were preformed on the mean scores of the question, recommendations, and overall performance for each case study for UNIS and the four nurse experts.

Results of Study One

A total of 854 questions were asked by UNIS and the four nurse experts collectively (Table 1). Results of the One-Way Repeated Measure Analysis of Variance (ANOVA) with experts (UNIS and the four nurse experts) as the repeated measure and the total mean ratings as the dependent variables were not statistically significant.

A total of 250 recommendations were evaluated (Table 2). The number of recommendations provided by UNIS and the four nurse experts ranged from 2 to 34. For each case study, mean total ratings were calculated for the ratings obtained on all the recommendations provided by UNIS and the four nurse experts.

Table 1
Total Number of Questions Asked by UNIS and the Four Nurse Experts on Five Case Studies

		Nurse Experts			
Cases	UNIS	1	2	3	4
1	42	19	28	32	11
2	99	26	23	36	6
3	30	41	41	38	23
4	101	16	26	30	4
5	78	15	37	34	18

Results of the ANOVA with the experts (UNIS and the four nurse experts) as the repeated measure and the total mean ratings as the dependent variables were not statistically significant.

Table 2
Total Number of Recommendations Provided by UNIS and the four Nurse Experts on Five Case Studies

		Nurse Experts			
Cases	UNIS	1	2	3	4
1	13	5	5	5	2
2	34	7	8	6	4
3	16	3	11	13	9
4	17	8	8	6	5
5	34	5	14	8	4

The scores for overall performance on the five case studies are displayed in Table 3. The range of possible scores was 6 to 18 (six evaluators with a maximum score of 3 per case study).

The results of the ANOVA were statistically significant: $F_{.01}$ (4,16) =10.40. UNIS scored the highest on four of the five case studies. A Post-Hoc Tukey's test was performed and significant differences were noted between: UNIS and Expert One, UNIS and Expert Four, Expert One and Two, and Expert Two and Four: Tcmd=6.318.

Table 3
Total Ratings Scores Assigned to each Case Study by the Nurse Evaluators

		Experts			
Cases	UNIS	1	2	3	4
1	10	6	13	8	6
2	17	6	16	16	6
3	16	7	8	9	6
4	17	16	16	13	6
5	18	6	12	7	12

Study Two: Clinical Performance of UNIS

Three nursing units, matched for staffing and patient characteristics, were randomly assigned to one of three treatments. Unit One had UNIS installed at the nurses' station for ten weeks and received two weeks of user support from a research assistant. Unit Two had UNIS installed at the nurses' station for ten weeks and received ongoing user support. A third unit served as a control group and was not exposed to UNIS (Control Unit).

Participants: There were two groups of participants: elderly, incontinent patients and nurses who cared for them in the nursing home.

All elderly, incontinent patients, who met the criteria for the study, were placed on a sampling list. Each patient was categorized according to their cognitive status using the Folstein's Mini-Mental Status Examination [4] as mild, moderate and severely impaired. Three patients from each category were randomly selected from the sampling list on each unit (N=27 patents with 9 on each unit).

All of the regular nursing personnel assigned to the three nursing units were asked to volunteer to participate in the study including nursing aides (NAs), certified medical assistants (CMAs), licensed practical nurses (LPNs) and registered nurses (RNs) (N=50).

Data Collection: Data was collected on the average number of wet occurrences each week for ten weeks and the nurses' knowledge of caring for patients with urinary incontinence.

To collect data on the occurrence of wetness, nurses on all three units were taught to perform a standardized check for wetness called a 'wet check' [5]. Nurses were instructed to check the patients every two hours while the patients were awake. Two weeks of baseline data were collected on the patients before UNIS was installed on the treatment units.

To collect data on the nurses' knowledge, case studies were presented to the nurses and their recommendations for care were recorded. Five case studies of elderly, incontinent patients were randomly selected from a pool of 50 case studies designed specifically for this study.

There were three versions of each case study for NA/CMAs, LPNs and RNs recorded on cassette tapes. Each nurse was asked to listen to the case studies and record their recommendations for assessment and treatment. Each nurse was tested four times during the study (baseline and every 3 weeks). A total of 20 case studies (5 per test x 4 test periods) were presented.

Two nurse experts were asked to rate the recommendations provided by the nurses for each case study on a scale from one to seven where one=adequate response and seven = equivalent to the specialist's response. A total of 35 points could be accumulated (5 case studies with a maximum score of 7 on each; maximum of 35 points per session).

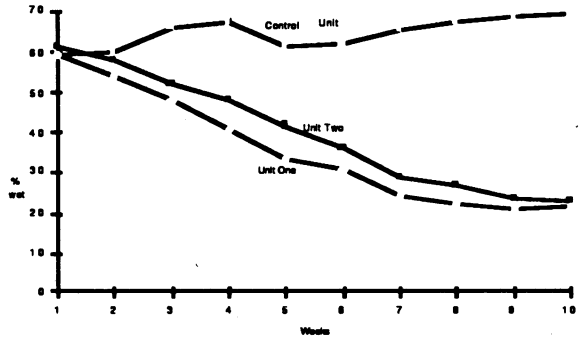
Results of Study Two

Due to patient transfers or illness, only six patients on each unit completed the study. The mean score on the mental status examination for patients on the Control Unit was 16. The mean scores for patients on the Treatment Units were 14 (Unit One) and 15 (Unit Two). The mean age for each group was 77.3, 72.6 and 78.4 respectively. The mean length of stay for the Control Unit was 56 weeks. The mean length of stay for the Treatment Groups were 16 weeks (Unit One) and 36 weeks (Unit Two).

A total of 7,200 wet occurrence recording were analyzed (400 checks x 18 patients). The main effect of unit assignment (Control Unit, Treatment One, Treatment Two was significant) $F_{.001}$ (2,81)=34.67 . The blocking variable of mental status was significant $F_{.001}$ (2,81)=50.79 as was the measure of time; $F_{.001}$ (9,81) =29.8. The only significant interaction was between unit assignment and time $F_{.001}$(18,81)=28.6.

As can be seen in Figure one below, the effect of nurses' using UNIS on the treatment units was accelerated following from the second week through the seventh week. During this time, patients on Unit One (where 2 weeks of training were given) were recorded as being dryer than patients on Unit Two (where ongoing training was provided). However, by the ninth week, the patients from both treatment groups averaged nearly the same number of wet occurrences. The data on the patients on the Control Unit indicated an increase in the average number of wet occurrences.

Figure 1
Comparison of Wet Occurrences by Unit over a Ten Week Period



A total of 50 nurses participated in the second study (Table 4). The average nursing experience was not significantly different between the three units and ranged from 6.2 years to 10.5 years. Since there were no RN's in the control group, the data for RNs was not in this analysis.

Table 4
Nurse Subjects by Title, Years of Nursing Experience and Computer Experience

	Control	Tx 1	Tx 2
RNs	0	1	1
Number of LPNs	2	5	2
Number of NA/CMAs	13	14	12

Each nurse had 20 scores obtained during 4 test sessions (5 case studies per test). Unit assignment and the measurement of time were both significant; $F_{.001}$ (2,157) =19.46 and $F_{.001}$ (3,157) = 191.22. The interaction between treatment and time was also significant; $F_{.001}$ (6,157) =45.29. The knowledge of nurses on the treatment group improved gradually over the first 5 weeks of the study and accelerated during the second 5 weeks of the study.

Discussion of Studies One and Two

Study One: In the first study, the results indicate that this prototype of UNIS is as effective at asking relevant questions and providing valuable recommendations as four nurse experts in the field. However, it is interesting to note that UNIS ask a larger number of questions and answers than any of the nurse experts. Additional ANOVAs were performed comparing the total number of questions and recommendations provided by UNIS and the nurse experts on each case study. The results of the ANOVA comparing the number of questions asked by the nurse experts and UNIS was significant; $F_{.05}$ (4,16) = 7.79. A total of 350 questions were displayed during sessions with UNIS; more than twice the amount of any other expert. A post-hoc Tukey's test was performed and significant differences were noted between UNIS and Expert 1 and UNIS and Expert 4; Tcmd=40.34.

The number of recommendations provided during sessions with UNIS was also significantly different from the number of recommendations provided by the four nurse experts $F_{.05}$ (4,16)=11.53. Sessions with UNIS resulted in a total of 114 recommendations; more than twice the amount of any other expert. A Post-Hoc Tukey's test was performed and significant differences were noted between UNIS and all four nurse experts; Tcmd=11.46.

Therefore, although the relevance of the questions asked and value of the recommendations were not significantly different, the interaction (number of questions and recommendations) was significantly different. The scores assigned by the evaluation panel may have been biased by the differences in the number of questions. It is interesting to note that Experts One and Four had the lowest overall performance scores. These two experts ask the least number of questions and provided the least number of recommendations. Future prototyping for UNIS will need to consider a model which better mimics Experts Two and Three in this study. Future evaluations will also need to include larger samples of case studies in the evaluation.

Study Two: In the second study, the results indicated that when nurses, caring for elderly, incontinent patients used UNIS, the number of wet occurrences significantly decreased. These results are very encouraging. It is not

clear what types of interventions (if any) were implemented by the nurses using UNIS to cause the patients to become dryer. These activities were not documented on the care plans and were not elicited from the nurses. Further research is needed to determine what nursing behaviors changed as a direct result of using UNIS. Differences between the patients will also need to be closely monitored. In this study, patients were blocked according to their mental status. But it is highly probable that other factors such as medical diagnoses, impacted the patients' responses to the nurses interventions.

It is interesting to note the differences in the patient data between Unit One and Unit Two. It would appear that patients in Unit One had more of an accelerated response to the nurses use of UNIS. This may be partially explained by the differences between the mean lengths of stay for patients on Unit One and patients on Unit Two. Those patients on Unit One were participating in an rehabilitation program and had a much shorter length of stay. Therefore, patients on Unit One can not be compared to the chronic care patients on the Control Unit. Patients on Unit Two were much more like those patients in the Control Group.

The nurses on Unit Two had ongoing user support whereas the nurses on Unit One received two weeks of user support. Varying the amount of user support did not seem to change the outcome of the patients. UNIS was used as effectively by nurses who received two weeks of user supports as those who received ten weeks of user support.

Using UNIS as a consultation system proved to be an effective training tool for the LPNs, NAs and CMAs. The method used to test the nurses' knowledge may require further refinement. Since specific content was not tested, there exists the possibility that the nurses simply became very good at regurgitating the information obtained from UNIS. Further research is needed to understand the relationships between nurses using UNIS, nurses' knowledge and nurses' behavior with elderly, incontinent patients.

Implementing UNIS in a nursing home setting was a difficult and time-consuming task. In the future, longer interventions are needed to help control the Hawthorne effect. In this study, the nurses were very excited about learning how to use a computer. A follow-up survey indicated that 100% of the nurses who used UNIS wanted to learn more about computers and enjoyed the experience. Nurses on the Control Group also expressed an interest in learning more about the system. They were given an opportunity to use UNIS after the research study was concluded.

Conclusion

UNIS was examined and proved to have merit for further development as an expert system. The results indicated that nurses in long-term care settings can successfully use expert systems for training and consultation and will do so with a great deal of enthusiasm when the system is presented to them in an appropriate manner.

Further research on UNIS is planned. A second version of UNIS is being developed for patients in outpatient settings. This version, known as UNIS II, will allow elderly patients to interact with UNIS in the physician's office.

References

[1] Ouslander, JG, Kane, RL & Abrass, IB (1982) Urinary incontinence in elderly nursing home patients. Journal of the American Medical Association, 248.

[2] Rowe, JW., (1988) Conference Chairman. Urinary incontinence in adults. National Institutes of Health Consensus Conference, October, Bethesda, Maryland.

[3] Blum, B. (1986) Artificial intelligence and medical informatics. Medical Informatics, 11:1.

[4] Folstein, M.F., Folstein, S., & McHugh, P.R. (1975) Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. Journal of Psychiatric Research. 12:189.

[5] McCormick, K.A., Scheve, A.S., Leahy, E. (1988) Nursing management of urinary incontinence in geriatric patients. Nursing Clinics of North America, 23:1, March.

This study was funded by the National Center for Nursing Research, National Institutes of Health, Grant # 52-1602314.

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