

Evaluation of the Decision Support Computer Program for Cancer Pain Management

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Purpose/Objectives: To evaluate a decision support computer program (DSCP) for cancer pain management.

Design: An Internet intervention study to evaluate the usage profile, accuracy, and acceptance of the DSCP.

Setting: Internet and community settings.

Sample: 122 nurses working with patients with cancer were recruited through the Internet through a convenience sampling method.

Methods: The instruments included tools for registration and for evaluation of the DSCP. To evaluate the DSCP, the usage profile was measured by counting the total number of cases in which the participants used the DSCP; accuracy was measured by determining whether the decision support from the DSCP was appropriate and accurate; and acceptance was measured using the Questionnaire for User Interaction Satisfaction.

Main Research Variables: Usage profile, accuracy, and acceptance of the DSCP.

Findings: Participants used the DSCP an average of 1.49 times per person (SD = 1.16). Eighty-eight percent of the participants evaluated the DSCP as appropriate and accurate. The mean scores of overall satisfaction in four major areas of the computer program ranged from 7.46–9.69.

Conclusions: The DSCP could provide accurate and acceptable computerized evidence-based practice guidelines for cancer pain management.

Implications for Nursing: The findings suggest that researchers should develop decision support systems in multiple aspects and dimensions of cancer pain experience and that hand-held devices would increase the usability of the DSCP.

Despite systematic efforts to standardize the management of cancer pain, researchers frequently have encountered multiple barriers to cancer pain assessment and management (Agency for Healthcare Research and Quality, 1994). Among them, the inadequate assessment of patient pain because of miscommunication between patients and healthcare providers was identified as the top barrier to good pain management, even when providers used currently available standardized measurement tools (Chan & Woodruff, 1997; Thomason et al., 1998). Additionally, gender and ethnic differences in pain descriptions were found to be significant factors influencing poor communication about cancer pain between patients and healthcare providers (Chan & Woodruff).

Depending on how healthcare providers make decisions and take action on the pain reported by their patients, the consequences for patients can vary (Sinclair, 1990). Some patients may experience peaceful ends to their lives; others might have pain until death. Healthcare providers' decision making regarding pain management is crucial, especially for people with chronic cancer pain, which needs continuous assessment and management (Trill & Holland, 1993). However, decision making with ambiguous and vague data on pain that cannot

Key Points . . .

- ▶ Acceptability to users is a major factor influencing the success of decision support systems.
- ▶ This decision support computer program could provide accurate and acceptable computerized evidence-based practice guidelines for cancer pain management.
- ▶ Hand-held devices may increase the usability of decision support systems at the bedside.

be assessed accurately even with the currently available standardized assessment tools is frequently problematic. Decision making is further complicated by many factors, such as differences in verbal and nonverbal communication, differences in pain expression, and culturally different attitudes toward pain control management (Robin, Vinard, Vernet-Maury, & Saumet, 1987). Moreover, the pressures of a fast-paced clinical setting make healthcare providers' decision making even more difficult.

To meet the healthcare needs of the United States' increasing ethnic minority populations (U.S. Census Bureau, 2000), the development of resources for nurses is imperative. Resources include a knowledge base on the gender and ethnic differences in cancer pain experiences and a computer program to support decision making about cancer pain. Such resources can help nurses improve the accuracy of their pain assessments and the adequacy of cancer pain management. However, very little is known about gender and ethnic differences in the experience of cancer pain, and very few computer programs supporting decision making on cancer pain assessment and management have been developed thus far.

In nursing, a few expert systems have been developed since the 1980s (Lowdermilk & Fishel, 1991; Probst & Rush, 1990; Sinclair, 1990). The programs allow nurses to modify their knowledge base with the addition of new information, thus increasing nurses' clinical effectiveness in the fields of nursing management, oncology nursing, and critical care nursing

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(Fonteyn & Grobe, 1994; Henry, 1995; Ito et al., 1995; Sinclair; Walker & Walker, 1994). The expert systems that nurses have developed include NursEXPERT (Thompson, 1992), Creighton Online Multiple Medical Expert System consultant system (Evans, 1988), FLORENCE nursing care planning system (Bradburn, Zeleznikow, & Adams, 1993), CANDI (Chang, 1988), the HELP Patient Care Information System (Bradshaw, Sitting, Gardner, Pryor, & Bredd, 1988), research knowledge system (Graves, 1990), Expert System for Education in Nursing Diagnosis (Koch & McGovern, 1993), CAREPLAN (Probst & Rush, 1990), Urological Nursing Information Systems (Petrucci & Petrucci, 1991), Intelligent System Access to Automated Clinical Charting (Bliss-Holtz, 1995), FLEXPART (Hendrickson & Paganelli, 1994), ISIRI prototype (Zanotti, 1994), PAT (Graves et al., 1994), Multi-Attribute Utility Decomposition (Brennan, 1988), ComputerLink (Brennan, Moore, & Smyth, 1992), and PAINReportIt and SymptomConsult (Wilkie et al., 2001). Among them, only PAINReportIt is for cancer pain management.

Im and Chee (2003) developed a decision support computer program (DSCP) that can be used as an assessment support tool for cancer pain experience. Based on fuzzy logic and modern control theory, the DSCP has decision rules, algorithms, and logics for classification of patients' pain according to gender and ethnicity. From those components, the program generates possible pain management strategies. It also includes a self-adaptation feature that incorporates new information from users and recalibrates the membership status of items according to the fuzzy logic. However, the DSCP was developed based on data from a small number of international oncology experts, and it never has been evaluated among oncology nurses in practical settings. Thus, evaluating the DSCP among oncology nurses working with patients from diverse ethnic groups is essential.

The purpose of the study reported in this article was to evaluate the DSCP by Im and Chee (2003) through an Internet intervention among nurses working with patients with cancer. Similar decision support programs have been used in the healthcare field since the 1950s, but the informatics literature has multiple definitions for a DSCP, which also is often called a computerized decision support system. Sometimes narrow and at other times broad, the definitions lead to confusion in terminology (Braden, Corritore, & McNeese, 1997). In the present study, a broad definition that enjoys some professional consensus was adopted: A DSCP refers to computer software employing a knowledge base (facts or rules) that is designed to be used by a clinician involved in patient care. Specific aims of the study were to examine the

- Usage profile of the DSCP by measuring the total number of cases in which participants used the DSCP
- Accuracy of the DSCP by measuring the total number of appropriate decisions made
- Acceptance of the DSCP by measuring user satisfaction when the DSCP is used for the first time.

More specific findings on the relationships between nurses' acceptance of the DSCP and their sociodemographic characteristics can be found elsewhere (Im & Chee, 2006).

The Decision Support Computer Program

Fuzzy logic by Zadeh (1965) contributed the theoretical foundation for development of the DSCP. In the current study,

fuzzy logic refers to the use of fuzzy sets in the representation and manipulation of vague information that follows from the recognition that real-world data do not fall neatly into discrete categories and that categories themselves are not discrete (Nguyen & Walker, 1997). Fuzzy sets are a mathematical methodology for expressing fuzzy concepts proposed by Zadeh. In contrast to conventional mathematical sets (termed "crisp sets"), each member of a fuzzy set has a membership function that represents the degree of its membership to the set.

Fuzzy logic has been used widely in the development of computer-assisted decision-making software and medical expert systems (Fathi-Torbaghan & Meyer, 1994; Halim, Ho, & Liu, 1990) and frequently has been used in clinical situations in medical fields characterized by uncertainty, imprecision, and vagueness (Fathi-Torbaghan & Meyer). Because pain tends to be described in ambiguous and vague terms, fuzzy logic is helpful in determining the decision-making process that healthcare providers frequently encounter when they treat pain.

The DSCP was developed based on numeric and verbal data collected among international oncology nursing experts using computer programming languages (C++ and Java). Detailed information on the DSCP can be found elsewhere (Im & Chee, 2003). The computer program itself has three major modules: a knowledge base generation module, a decision-making module, and a self-adaptation module. The knowledge base generation module contains a generic knowledge base and a culture-specific knowledge base. The generic knowledge base was constructed by searching common fuzzy sets from the collected fuzzy sets. The culture-specific knowledge base was developed based on the remaining fuzzy sets that were not included in the generic knowledge base. The decision-making module consists of two sets of fuzzy inference logic: inference logic with a generic knowledge base and inference logic with a culture-specific base. Each fuzzy inference logic was developed by using a genetic algorithm (Wang, 1994). Then, the decision-making module was developed to provide suggestions for pain management strategies according to gender and ethnicity. The decision-making module also incorporated the World Health Organization's (1996) suggestions for cancer pain management.

Methods

The DSCP was loaded onto a Web site that was dedicated for the project, and oncology nurses were asked to use the DSCP via the Internet. At the end of the user sessions, participants were asked questions about the usage profile, accuracy, and acceptance of the DSCP.

Sample and Settings

The settings for the study included both Internet and community settings. The Internet settings included Web sites and Web pages of (a) U.S. nursing professional organizations, (b) Internet groups and communities for RNs, (c) schools of nursing in the United States, and (d) any types of nursing organizations and institutions in the United States. The community settings included (a) local nursing professional organizations across the United States and (b) local hospitals and institutions across the United States. Through the settings, 122 RNs working with patients with cancer were recruited.

An announcement of the study was distributed through the Web sites and pages of 136 nursing professional organizations,

all the Internet communities and groups for nurses on MSN.com and AOL.com, 44 schools of nursing in the United States, and managers of 262 student organizations, 402 local organizations and institutions, and 629 health departments and nursing homes in the United States. In addition, a study announcement e-mail was sent to a total of 9,682 individual e-mail addresses obtained through an Internet search. For the community settings, the snowball sampling method was used. Because all research staff members were RNs, colleagues of the research staff members were first contacted to recruit RNs working with patients with cancer. Then they were asked to distribute the electronic and paper copies of the study flyers to anyone who might be interested in the study.

Through the process, when RNs who were working with patients with cancer agreed to use the DSCP, they were asked to visit the project Web site, register for the study, and use the DSCP on the Web site. When the RNs registered, they were given IDs and passwords.

The research participants were (a) self-identified RNs with active status, (b) working in clinical or homecare settings related to cancer pain assessment and management, (c) caring for patients with cancer, and (d) able to read and write in English.

Because the study did not include hypotheses, the data analysis focused on descriptive statistics. In descriptive studies, 30 subjects usually are considered to be the minimum sized population (Burns & Grove, 1997). Thus, 122 participants are an adequate number for the descriptive purpose of the study.

Instruments

The instruments used in the study were for registration and the DSCP evaluation. For registration, the data on participants themselves were collected using nine questions on sociodemographic characteristics, including job title, work setting, specialty, age, gender, education, religion, marital status, ethnicity, country of birth, state of residency, family income, and satisfaction with family income.

To evaluate the DSCP, the usage profile of the program, the accuracy of the program, and the acceptance by the target users were evaluated per Reisman's (1996) recommendations. The **usage profile** of the program was measured by a count of the total number of cases for which participants received support for decisions they were making about cancer pain cases through the DSCP. Participants rated the **accuracy** of the program by indicating whether the decision support from the DSCP was appropriate and accurate. **Acceptance** by the target users was measured with the **Questionnaire for User Interaction Satisfaction (QUIS)** by Chin, Diehl, and Norman (1988), only after the participants used the DSCP for the first time. The QUIS was developed by Shneiderman (1987). The original QUIS consisted of 90 questions: five questions on overall reaction ratings of the system and 85 questions on the system's main components. Through empirical studies, the original QUIS has been upgraded several times. Version 5.0 as updated by Chin et al. was used in the study reported in this article. This version includes 27 questions in five sections: (a) overall reaction to the software, (b) screen, (c) terminology and system information, (d) learning, and (e) system capabilities. Each item has a rating scale from 1–10. The overall reliability of the QUIS was 0.94 (Cronbach's alpha), interitem alpha values were from 4.72–7.02 ($SD = 1.67$ – 2.25), and the item analysis indicated good discriminability in the overall reaction ratings.

Data Collection Procedures

A Web site conforming to University of Texas policies and Health Insurance Portability and Accountability Act regulations related to electronic transmissions was developed and published on an independent server dedicated to this project. The project Web site contained the informed consent sheet about the study, the DSCP, the instruments for registration, and the instruments for evaluating the DSCP. As described previously, the study was announced through multiple recruitment sources on the Internet and in real settings. The announcement included information about contact numbers, e-mail addresses, the project Web site address, data collection procedures, the dates data were to be collected, how the data would be used, and how participation would be reimbursed. The opening page of the project Web site explained the general purpose of the study. The visitors were asked to click to enter the informed consent sheet. All instruments also included a paragraph saying, "Answering the following questions means that you are at least 18 years of age and you agree to participate in this study." Informed consent was obtained via the project Web site, which presented potential participants with a button to click that said, "I agree," after the site had ensured that they met the inclusion criteria. When potential participants clicked the button, thereby agreeing to participate, they were asked to register for the study by providing information about themselves. The only information connected to a participant's identity was an e-mail address, which was used solely for reimbursement for their participation. When they registered, they could choose their IDs and passwords to log on to the project Web site. Whenever participants visited the Web site, they were required to use the IDs and passwords for access.

After giving informed consent, visitors were asked to use the DSCP and generate cancer pain management strategies. In future sessions with the DSCP, they were asked about the accuracy of the DSCP via a question on the Web site. If they did not return within a week, an e-mail asking the question about the accuracy of the DSCP was sent to them. If they did not respond to the e-mail within a week, the e-mail message was sent again. The answers were entered in the data file by a research staff member and double checked by another research staff member. The same procedure then was repeated whenever participants used the DSCP. Their visits were recorded and counted automatically. When the intervention was finalized, the total amount of DSCP usage by each participant was counted.

Data Analysis

The collected data were saved automatically in ASCII format on disk and removed from the server to ensure confidentiality. The data were dealt with confidentially, and no individual identities were used throughout the analysis process. Serial ID numbers that the researchers randomly assigned were attached to the data.

The data entered for registration and the data entered to evaluate the DSCP were analyzed using SPSS version 11.5 (SPSS Inc., Chicago, IL). The accuracy of data entry was ensured through saving the data as ASCII files directly from the Web site and through double checking by research staff members. In addition, data were checked for outliers and missing data. Participants with 10% or more data missing

were not included in the analyses. For participants with less than 10% missing data, mean substitution was used to determine the value of missing data. After the data analysis, all raw data were maintained in a locked file cabinet in the study office. The sociodemographic characteristics of the participants were described with statistics, including frequency, percentage, mean, standard deviation, and range, as were the total number of cases for which the participants used the DSCP, the total number of appropriate decisions made, and user satisfaction levels.

Findings

Sociodemographic characteristics of the participants are summarized in Table 1. The total number of times the participants used the DSCP was 126. The average number of times that an individual used the DSCP was 1.49 (SD = 1.16).

Accuracy

On the scale of 0–100, the mean agreement score of participants to strategies generated by the DSCP was 91.30 (SD = 21.93). After they used the DSCP, 88% of participants evaluated it as appropriate and accurate. The reasons for inappropriateness included (a) ineffectiveness of pain medication (it only decreased pain without alleviating pain), (b) death of the patients, (c) inappropriate route for medication (e.g., patients could not swallow the medication), (d) physicians' orders for different medications, and (e) patients' complaints of sleepiness.

User Satisfaction

The mean scores of overall satisfaction in four major areas of the computer program ranged from 7.46–9.69 (on a 1–10 scale). The mean scores in the area of overall satisfaction with the computer program were 7.46–8.67; those with screen layout and design were 8.77–9.26; those with terminology and system information were 8.59–9.31; those with users' learning process were 8.52–9.51; and those with system capabilities were 8.75–9.52. The lowest mean score was for the item "level of satisfaction" ($\bar{X} = 7.46$, SD = 2.55). The highest score was for the item "position of messages on screen" ($\bar{X} = 9.69$, SD = 0.62). Table 2 summarizes the overall satisfaction of the participants with the DSCP.

Discussion

In healthcare fields, several decision support systems have been developed (Burke & Weill, 2000). As mentioned previously, decision support systems have been used, especially in nursing, mainly for educational (Lowdermilk & Fishel, 1991; Sinclair, 1990) and clinical purposes in the field of nursing management, oncology nursing, and critical care nursing (Fonteyn & Grobe, 1994; Ito et al., 1995). Despite the overall positive view of the DSCP in nursing practice, very few computer programs have been developed to support nurses' decision making in a specific nursing encounter involving cancer pain (Huang, Wilkie, & Berry, 1996; Wilkie et al., 2001). Furthermore, most of the few programs have been developed as a method for evaluating clinical decision making rather than actually assisting it.

A criticism of the expert systems is that an expert system based exclusively on the knowledge of one expert may not necessarily be valid when applied by other experts (Woolley,

Table 1. Sociodemographic Characteristics

Characteristic	n	%
Age (years)		
$\bar{X} = 40.26$	–	–
SD = 10.36	–	–
Education		
Partial college	6	5
College	67	55
Graduate degree	49	40
Residency		
Northeast	26	21
South	57	47
Midwest	20	16
West	19	16
Born in the United States		
Yes	89	73
No	33	27
Family income amount (\$)		
Less than 10,000	3	3
10,001–20,000	1	1
20,001–30,000	4	3
30,001–50,000	21	17
50,001–70,000	24	20
70,001–100,000	44	36
More than 100,000	25	21
Gender		
Female	114	93
Male	8	7
Marital status		
Married	72	59
Divorced	18	15
Partnered	10	8
Single	20	16
Widowed	2	2
Satisfaction with family income		
Totally insufficient	3	3
Somewhat insufficient	17	14
Sufficient	66	54
More than sufficient	36	30
Ethnic identity		
Caucasian	91	75
Asian	20	16
Hispanic	5	4
African	4	3
Mixed	2	2
Religion		
Protestant	60	49
Catholic	35	29
Buddhist	8	7
Moslem	1	1
No religion	13	11
Other	5	4

N = 122

Note. Because of rounding, not all percentages total 100.

1991). Other criticisms concern task domains that are unsuitable for the expert system, lack of relevant databases for development of expert systems, and ineffectively presented content (Chang & Hirsch, 1991; Mallach, 2000). Knowledge acquisition also has been critiqued as the weakest link in the design of expert systems (Henry, 1995).

The study findings presented in this article demonstrated that nurses do welcome decision support systems. Eighty-eight percent of the participants evaluated the DSCP as appropriate and

Table 2. Summary of Participants' Satisfaction With the Decision Support Computer Program

Area of Satisfaction	\bar{X}	SD
Overall reaction to the software		
Level of enjoyment	8.11	1.57
Level of ease	8.67	1.78
Level of satisfaction	7.46	2.55
Level of power	8.03	2.18
Level of stimulation	7.62	2.12
Level of flexibility	7.72	2.43
Screen		
Characters on the computer screen	9.26	1.44
Highlighting simplifies task.	8.77	1.79
Organization of information	8.95	1.53
Sequence of screens	8.98	1.59
Terminology and system information		
Use of terms	9.31	0.89
Computer technologies	8.93	1.52
Position of messages	9.03	1.47
Messages that prompt user for input	8.84	1.83
Computer keeps you informed.	8.62	1.64
Error messages	8.59	1.63
Learning		
Learning to operate the system	9.51	0.77
Exploring new features by trial and error	9.16	1.09
Remembering names and use of commands	9.16	1.25
Tasks are performed in a straightforward manner.	9.10	1.27
Help messages	9.00	1.29
Supplemental reference materials	8.52	1.81
System capabilities		
System speed	9.52	0.77
System reliability	9.10	1.38
System quietness	9.69	0.62
Correcting mistakes	9.28	1.51
Users' needs are taken into consideration.	8.75	1.46

Note. All scales ranged from 1–10.

accurate. Even in the cases where some of the participants did not agree about the appropriateness of the system's responses, the major reasons were uncontrollable and unpredictable, as in the case of physicians' orders and patients' conditions (e.g., death, inability to swallow). Overall, the findings supported that participants were satisfied with the DSCP in terms of the four major aspects of the computer program: (a) overall satisfaction with the software, (b) screen layout and design, (c) terminology and system information, and (d) users' learning process.

Participants were allowed to use the DSCP as many as three times, yet the average number of uses was only 1.49 times. One of the possible reasons for the low usage of the DSCP is the difficulty in accessing the DSCP at the bedside. Because the DSCP was available only through the Internet, nurses needed to use laptop or desktop computers to access the DSCP. As a result, instead of using the DSCP at the bedside, participants had to use it at nursing stations. Not only

might this alter the data, but it also burdened nurses' regular schedules in clinical settings with extra duties.

A limitation of the study is potential selection biases resulting from diverse recruitment settings. Although participants were recruited through multiple Internet and community settings, they tended to be highly educated nurses with high incomes. Another limitation of the study is related to the authenticity of Internet communication and multiple submissions by the same person. Although the computer server-side program checked the Internet protocol (IP) addresses of the visitors at the project Web site, the program could not block multiple submissions by the same person using different usernames and passwords. Because the authors expected that several nurses working in the same setting could participate together, multiple participants were not blocked from using the same IP addresses, although IP addresses were monitored.

Implications

The DSCP for cancer pain management was evaluated through actual data collection among nurses working with patients with cancer. The findings strongly support the accuracy and acceptability of the DSCP and suggest that it could provide accurate and acceptable computerized evidence-based practice guidelines for cancer pain management. However, the actual usages of the DSCP by the nurses tended to be limited because of the Internet deployment of the DSCP. Based on the study findings, this article concludes with two suggestions for future research on the development of decision support systems for cancer pain management.

First, researchers should continuously develop decision support systems for cancer pain management in the multiple aspects and dimensions of cancer pain experience. Depending on the focus of the program (in the case of this DSCP, the focus was on gender and ethnic differences in cancer pain experience), the decision support systems would address different aspects of the cancer pain management process. With the various decision support systems, nurses could more appropriately and adequately manage pain of patients from diverse ethnic groups.

Second, researchers should consider using hand-held devices for development of their decision support systems. As previously mentioned, one important feature of the DSCP that was refined and evaluated through the study was Internet deployment—whereby users could access the DSCP through Web browsers without any installations so they could use the most up-to-date knowledge base. Yet some of the participants reported difficulties in using the Internet version of the DSCP at the bedside, where they could actually hear pain descriptions, because they could not take a laptop computer whenever they managed patients' pain. Hand-held devices may increase the usability of the DSCP at the bedside.

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References

- Agency for Healthcare Research and Quality. (1994). *Management of cancer pain* [Pub. no. 94-0592]. Rockville, MD: Author.
- Bliss-Holtz, J. (1995). Computerized support for case management ISAACC. *Computers in Nursing, 13*, 289–294.
- Bradburn, C., Zeleznikow, J., & Adams, A. (1993). FLORENCE: Synthesis of case-based and model-based reasoning in a nursing care planning system. *Computers in Nursing, 11*, 20–24.
- Braden, B.J., Corritore, C., & McNees, P. (1997). Computerized decision support systems: Implications for practice. *Studies in Health Technology and Informatics, 46*, 300–304.

- Bradshaw, K., Sitting, D., Gardner, R., Pryor, T., & Bredd, M. (1988). Improving efficiency and quality in a computerized ICU. In R.A. Greene (Ed.), *Proceedings of the 12th Annual Symposium on Computer Applications in Medical Care* (pp. 763–768). Los Angeles: IEE Computer Society Press.
- Brennan, P.F. (1988). Modeling for decision support. In M.J. Ball, K.J. Hannah, U. Gerdin, & H. Paterson (Eds.), *Nursing informatics: Where caring and technology meet* (pp. 267–273). New York: Springer-Verlag.
- Brennan, P.F., Moore, S.M., & Smyth, K.A. (1992). Alzheimer's disease caregivers' uses of a computer network. *Western Journal of Nursing Research*, 14, 662–673.
- Burke, L., & Weill, B. (2000). *Information technology for the health professions*. Upper Saddle River, NJ: Prentice Hall.
- Burns, N., & Grove, S.K. (1997). *The practice of nursing research: Conduct, critique, and utilization*. Philadelphia: Saunders.
- Chan, A., & Woodruff, R.K. (1997). Communicating with patients with advanced cancer. *Journal of Palliative Care*, 13(3), 29–33.
- Chang, B. (1988). CANDI: A knowledge-based system for nursing diagnosis. *Computers in Nursing*, 7, 222–227.
- Chang, B., & Hirsch, M. (1991). Knowledge acquisition and knowledge representation in a rule-based expert system. *Computers in Nursing*, 9, 174–178.
- Chin, J.P., Diehl, V.A., & Norman, K.L. (1988). Development of a tool measuring user satisfaction of the human-computer interface. In *CHI '88 conference proceedings: Human factors in computing* (pp. 213–218). New York: Association for Computing Machinery.
- Evans, S. (1988). The COMMES nursing consultant system—A practical clinical tool for patient care. *Proceedings of Nursing and Computers, Third International Symposium on Nursing Use of Computers and Information Science* (pp. 806–824). St. Louis, MO: Mosby.
- Fathi-Torbaghan, M., & Meyer, D. (1994). MEDUSA: A fuzzy expert system for medical diagnosis of acute abdominal pain. *Methods of Information in Medicine*, 33, 522–529.
- Fonteyn, M.E., & Grobe, S.J. (1994). Expert system development in nursing: Implications for critical care nursing practice. *Heart and Lung*, 23, 80–87.
- Graves, J.R. (1990). A research-knowledge system (ARKS) for storing, managing, and modeling knowledge from the scientific literature. *Advances in Nursing Science*, 13(2), 34–45.
- Graves, J.R., Fehlauer, C.S., Gillis, P.A., Booth, H., Vaux, C., & Soller, J. (1994). Mobile pen-based technology as the interface of a clinical information system: A panel presentation. In S.J. Grobe & E.S. Ployter-Wenting (Eds.), *Nursing informatics: An international overview for nursing in a technological era* (pp. 730–733). New York: Elsevier.
- Halim, M., Ho, K.M., & Liu, A. (1990). Fuzzy logic for medical expert systems. *Annals of the Academy of Medicine, Singapore*, 19, 672–683.
- Hendrickson, M.H., & Paganelli, B. (1994). Facing the challenges of nurse expert systems of the future. In S.J. Grobe & E.S. Ployter-Wenting (Eds.), *Nursing informatics: An international overview for nursing in a technological era* (pp. 336–340). New York: Elsevier.
- Henry, S.B. (1995). An inductive algorithm approach to knowledge acquisition for expert system development: A pilot study. *Computers in Nursing*, 13, 226–232.
- Huang, H.Y., Wilkie, D.J., & Berry, D.L. (1996). Use of a computerized digitizer tablet to score and enter visual analogue scale data. *Nursing Research*, 45, 370–372.
- Im, E.O., & Chee, W. (2003). Decision support computer program for cancer pain management. *Computers, Informatics, Nursing*, 21, 12–21.
- Im, E.O., & Chee, W. (2006). Nurses' acceptance of the decision support computer program for cancer pain management. *Computers, Informatics, Nursing*, 24, 95–104.
- Ito, M., Ramos, M.P., Chern, M.S., Esposito, S.R., Carmagnani, M.I., Cunha, I.C., et al. (1995). Decision support system for individualized nursing procedures: SAPIEN-Tx. *Medinfo*, 8, 1378–1381.
- Koch, B., & McGovern, J. (1993). EXTEND: A prototype expert system for teaching nursing diagnosis. *Computers in Nursing*, 11, 35–40.
- Lowdermilk, D.L., & Fishel, A.H. (1991). Computer simulations as a measure of nursing students' decision-making skills. *Journal of Nursing Education*, 30, 34–39.
- Mallach, E.G. (2000). *Decision support and data warehouse systems*. Boston: McGraw-Hill.
- Nguyen, H.T., & Walker, E.A. (1997). *A first course in fuzzy logic*. Boca Raton, FL: CRC Press.
- Petrucci, K., & Petrucci, P. (1991). Expert systems and nursing. *Nursing Economic*, 9, 188–190.
- Probst, C.L., & Rush, J. (1990). The CAREPLAN knowledge base. A prototype expert system for postpartum nursing care. *Computers in Nursing*, 8, 206–213.
- Reisman, Y. (1996). Computer-based clinical decision aids. A review of methods and assessment of systems. *Medical Informatics*, 21, 179–197.
- Robin, O., Vinard, H., Vernet-Maury, E., & Saumet, J.L. (1987). Influence of sex and anxiety on pain threshold and tolerance. *Functional Neurology*, 2, 173–179.
- Shneiderman, B. (1987). *Designing the user interface: Strategies for effective human-computer interaction*. Reading, MA: Addison-Wesley.
- Sinclair, V.G. (1990). Potential effects of decision support systems on the role of the nurse. *Computers in Nursing*, 8, 60–65.
- Thomason, T.E., McCune, J.S., Bernard, S.A., Winer, E.P., Tremont, S., & Lindley, C.M. (1998). Cancer pain survey: Patient-centered issues in control. *Journal of Pain and Symptom Management*, 15, 275–284.
- Thompson, B.W. (1992). NursEXPERT: A nursing diagnosis assessment expert system. In J.M. Arnold & G.A. Pearson (Eds.), *Computer application in nursing education and practice* (pp. 253–259). New York: National League for Nursing.
- Trill, M.D., & Holland, J. (1993). Cross-cultural differences in the care of patients with cancer. A review. *General Hospital Psychiatry*, 15, 21–30.
- U.S. Census Bureau. (2000). *Resident population estimates of the United States by sex, race, and Hispanic origin*. Washington, DC: Author.
- Walker, P.H., & Walker, J.M. (1994). Informatics for nurse managers: Integrating clinical expertise, business applications, and technology. *Seminars for Nurse Managers*, 2(2), 63–71.
- Wang, L.X. (1994). *Adaptive fuzzy systems and control: Design and stability analysis*. Englewood Cliffs, NJ: Prentice Hall.
- Wilkie, D.J., Huang, H.Y., Berry, D.L., Schwartz, A., Lin, Y.C., Ko, N.Y., et al. (2001). Cancer symptom control: Feasibility of a tailored, interactive computerized program for patients. *Family and Community Health*, 24(3), 48–62.
- Woolley, N. (1991). Adjuncts to the nurse's skills? Advantages and disadvantages of expert systems. *Professional Nurse*, 12, 722–726.
- World Health Organization (1996). *Cancer pain relief: With a guide to opioid availability* (2nd ed.). Geneva: Author.
- Zadeh, L.A. (1965). Fuzzy sets. *Information and Control*, 8, 338–353.
- Zanotti, R. (1994). Decision making in nursing care process: A systematic computerization. In S.J. Grobe & E.S. Ployter-Wenting (Eds.), *Nursing informatics: An international overview for nursing in a technological era* (pp. 348–352). New York: Elsevier.