

ONLINE CONTENT

A brief history of nursing informatics in the United States of America

Judy G. Ozbolt, PhD, RN, FAAN, FACMI, FAIMBE
Virginia K. Saba, EdD, RN, FAAN, FACMI, LL

From the beginning of modern nursing, data from standardized patient records were seen as a potentially powerful resource for assessing and improving the quality of care. As nursing informatics began to evolve in the second half of the 20th century, the lack of standards for language and data limited the functionality and usefulness of early applications. In response, nurses developed standardized languages, but until the turn of the century, neither they nor anyone else understood the attributes required to achieve computability and semantic interoperability. Collaboration across disciplines and national boundaries has led to the development of standards that meet these requirements, opening the way for powerful information tools. Many challenges remain, however. Realizing the potential of nurses to transform and improve health care and outcomes through informatics will require fundamental changes in individuals, organizations, and systems. Nurses are developing and applying informatics methods and tools to discover knowledge and improve health from the molecular to the global level and are seeking the collective wisdom of interdisciplinary and interorganizational collaboration to effect the necessary changes.

NOTE: Although this article focuses on nursing informatics in the United States, nurses around the world have made substantial contributions to the field. This article alludes to a few of those advances, but a comprehensive description is beyond the scope of the present work.

IN THE BEGINNING . . .

There is a growing conviction that in all hospitals, even in those which are best conducted, there

Judy G. Ozbolt, PhD, RN, FAAN, FACMI, FAIMBE, is a Professor and Program Director, Nursing Informatics, University of Maryland, Baltimore, MD.

Virginia K. Saba, EdD, RN, FAAN, FACMI, LL, is CEO, SabaCare, Inc., Arlington, VA, and a Distinguished Scholar, Adjunct, Georgetown University, Washington, DC.

Corresponding author: Dr. Judy G. Ozbolt, University of Maryland School of Nursing, Organizational Systems & Adult Health, 655 West Lombard Street, Suite 455, Baltimore, MD 21201-1579.

E-mail: Ozbolt@son.umaryland.edu

Nurs Outlook 2008;56:199-205.

0029-6554/08/\$—see front matter

Copyright © 2008 Mosby, Inc. All rights reserved.

doi:10.1016/j.outlook.2008.06.008

is a great and unnecessary waste of life; . . . In attempting to arrive at the truth, I have applied everywhere for information, but in scarcely an instance have I been able to find hospital records fit for any purpose of comparison. If they could be obtained, they would enable us to decide many other questions besides the one alluded to . . . [I]f wisely used, these improved statistics would tell us more of the relative value of particular operations and modes of treatment than we have any means of obtaining at present. They would enable us, besides, to ascertain the influence of the hospital . . . upon the general course of operations and diseases passing through its wards; and the truth thus ascertained would enable us to save life and suffering, and to improve the treatment and management of the sick”

—Florence Nightingale¹

With those prophetic words, Florence Nightingale planted the seeds of 3 intertwined health sciences: health services research, evidence-based practice, and nursing informatics. One hundred thirty-seven years before the Institute of Medicine startled the world by estimating that medical errors were killing up to 98 000 hospitalized Americans annually,² Nightingale called for standardized clinical records that could be analyzed to assess and improve care processes and patient outcomes. Nursing informatics thus springs from the roots of modern nursing.

Nearly a hundred years would pass before Harriet Werley began to nurture the growth of nursing informatics. In the late 1950's, as the first designated nurse researcher at the Walter Reed Army Research Institute, Werley was one of a handful of people asked by IBM to provide consultation about possible uses of computers in health care. True to Nightingale's vision, Werley foresaw the potential for using patient data stored in computer systems to investigate and improve the quality of care. A prerequisite would be a minimum set of standardized nursing data to be collected on every patient.³

At that time, the very notions of nursing research and nursing science were novel, and there was little understanding of the nature and uses of a possible nursing minimum data set. Werley persevered, however, in promoting research fundamental to what would later emerge as nursing informatics. In 1960, the American Nurses' Association appointed a committee to identify priorities for investigation. Werley convinced the group to include a focus on nurses' use of information in communicating and decision-making.⁴

THE 1970'S

The first reports of "computer applications in nursing" began to appear in the professional and scholarly literature in the early 1970's. Nursing care planning systems aimed to relieve the burden of documentation and to improve the quality and completeness of the plan.^{5,6} A similarly practical system managed scheduling of patient activities in a rehabilitation center.⁷ Nurses at the El Camino Hospital in Mountain View, California, participating in developing the first comprehensive hospital information system (the Technicon Medical Information System, now owned by Eclipsis) recommended an integrated system for nursing care planning, documentation, and feedback.^{8,9} The standard care plans they developed, to be modified according to individual patient needs, were forerunners of today's evidence-based protocols and pathways.¹⁰

In addition to the El Camino project, the National Center for Health Services Research (NCHSR, a predecessor of today's Agency for Healthcare Quality and Research, or AHRQ) supported development of other early healthcare information systems that included nursing care planning and documentation.¹¹ At the same time, the Department of Defense was developing the Tri-Service Medical Information System (TRIMIS), and the Veterans Health Administration was starting to create its own clinical medical record system.

Another federal agency supporting projects to advance nursing informatics in the 1970's was the Division of Nursing (DN) of the Bureau of Health Manpower in the Health Resources Administration (now the Bureau of Health Professions, Health Resources and Services Administration). The DN was then the principal federal funding source for nursing research as well as nursing education. Beginning in 1975, a series of grants to the Visiting Nurse Association of Omaha, Nebraska, enabled DeLanne Simmons, Karen Martin, and colleagues to develop the Omaha System, standardized data elements and forms for collecting home care data. The intent was to use the data in paper-based or computer-based record systems to improve care and to meet reporting requirements.^{12,13}

Indeed, new Medicare and Medicaid legislation included complex reporting requirements that were difficult for community health agencies to meet with paper-based systems. Virginia Saba in the DN and Goldie

Levenson in the National League for Nursing conducted the first national conference and several state-of-the-art workshops on computerized management information systems for community health agencies. To support development of such systems, the DN funded not only the Omaha Visiting Nurse Association, but also other agencies, including the Rockland County, New York, Health Department and some states, including New Jersey and Florida.¹⁴

Nurses in the 1970's were also involved in interdisciplinary efforts to develop and implement applications to support health care. Kathleen McCormick and Carol Romano were among the nurses helping to adapt and implement the Technicon Medical Information System at the Clinical Center of the National Institutes of Health. Rita Zielstorff had been hired early into the Laboratory of Computer Science at Massachusetts General Hospital, where, under medical informatics pioneer Octo Barnett, MD, she contributed a nursing perspective to a number of grant-funded projects. These included the first paperless physician order entry and medication administration record with significant decision support,¹⁵ an automated record system for nurse practitioners in ambulatory care,¹⁶ and a multidisciplinary computer-based record for long-term care and research.¹⁷ By the late 1970's, the *Journal of Nursing Administration* featured a monthly column on computer applications in nursing, edited by Zielstorff, who soon compiled one of the first textbooks in the field.¹⁸

Other early nursing informatics research addressed fundamental questions of nursing knowledge representation and decision support. Inspired by decision-support systems to facilitate medical diagnoses, investigators at the University of Michigan developed prototypes to formulate nursing diagnoses from assessment data.^{19,20} These early efforts necessarily used ad hoc approaches because, at their inception, there were no definitions of nursing diagnosis in the literature, and the conceptual work to define and model nursing data and information in standard, computable ways would not occur for another 30 years. The group that would become the North American Nursing Diagnosis Association held its first meeting in 1973, identifying an initial set of 37 nursing diagnoses.^{21,22} Like the early researchers, these nurses worked without the knowledge of the then undefined desired attributes for standard language in clinical information systems.²³

To sharpen the focus and promote the advancement of the development and implementation of computer applications in nursing, Harriet Werley and Margaret Grier convened an invitational conference of "individuals knowledgeable about and interested in identifying and computerizing data bases relevant to nursing care."²⁴ Participants identified types of data and applications potentially useful in patient

care, management, education, and research, helping to shape the further development of the field.

THE 1980'S

Nursing informatics gained momentum in the 1980's. The introduction of the personal computer in 1980 facilitated small-scale prototyping of nursing informatics applications. In 1981, Virginia Saba organized a track for nursing papers at the Symposium on Computer Applications in Medical Care (SCAMC). In that year, too, the Clinical Center at the National Institutes of Health hosted its first national conference on Computer Technology and Nursing, with co-sponsors the Division of Nursing of HRSA and the TRIMIS project of the Department of Defense. In 1982, the International Medical Informatics Association (IMIA) sponsored the first of its triennial conferences in nursing informatics. Professional associations and schools of nursing also offered workshops and conferences.

As scholarship in nursing informatics flourished, nursing informatics leaders introduced informatics courses in schools of nursing. Among the first were Judith Ronald at the State University of New York, Buffalo, Virginia Saba at Georgetown University, and Diane Skiba at Boston College. With a growing record of accomplishment in informatics research, development, and education, nurses began to move into leadership positions in interdisciplinary health informatics. Judy Ozbolt became the first nurse elected to the board of directors of SCAMC and a founding board member of SCAMC's successor organization, the American Medical Informatics Association (AMIA).¹⁴

By the mid-1980's, reflecting the growing concern that nursing demonstrate its distinct contributions to patient care and the value of those contributions to patient outcomes, the profession's leaders were ready to embrace the idea of a nursing minimum data set. Almost 3 decades after proposing the idea, Werley, in collaboration with Norma Lang, convened a working conference and post-conference work group to define 16 data elements to be collected on all patients and abstracted from the record for studies of costs and effectiveness. Four uniquely nursing elements were nursing diagnosis, nursing intervention, nursing outcome, and intensity of nursing care.²⁵

Although there was agreement on the data elements, there was no resolution to the question of how to operationalize the elements. Evolving nursing languages offered several possibilities. The Omaha System demonstrated a practical approach to recording nursing diagnoses, interventions, and outcomes. The North American Nursing Diagnosis Association (NANDA) continued to meet and add to its roster of nursing diagnoses. Meanwhile, Joanne McCloskey, Gloria Bulechek, and colleagues at the University of Iowa began to develop the Nursing Interventions Classification (NIC) to describe what nurses do.²⁶

As scholarship, education, and practice grew through the 1980's, nursing informatics was gaining recognition as a distinct specialty in nursing. The American Nurses Association and the National League for Nursing established, respectively, a Council (1984) and a Forum (1985) on Computer Applications in Nursing. The 2 associations were instrumental in promoting nursing informatics nationally and internationally. They developed educational materials, passed resolutions, and recommended practice strategies and professional competencies.

In 1988, with Dean Barbara Heller at the helm and Carole Gassert and Mary Etta Mills designing the curriculum, the University of Maryland opened the first graduate education program in nursing informatics. The following year, Judith Graves and Sheila Corcoran published their seminal paper defining nursing informatics as a scientific discipline uniting nursing science, information science, and computer science to manage and process nursing data, information, and knowledge in support of nursing practice.²⁷ Graves and Corcoran distinguished data, information, and knowledge as representing successive levels of interpretation, aggregation, and generality.

It was also in 1989 that the National Center for Nursing Research (later the National Institute for Nursing Research) gave further recognition to the scientific basis of nursing informatics by convening an expert panel chaired by Judy Ozbolt to identify priorities for research in the field. Although the identified needs for research were broad-ranging, from ergonomics to organizational change, the report recognized that establishment of data standards was fundamental to unleashing the potential of nursing informatics to improve practice. Only with standardized data would nurses be able to translate knowledge to practice via decision support, and to create new knowledge from the data generated in nursing practice.²⁸

THE 1990'S

The technological advances of the 1990's were remarkable. The introduction of the Internet enabled communication and collaboration across distances, and the emergence of Web-based applications made it possible to transfer health information across previously incompatible hardware and software platforms. Computers became smaller, lighter, and faster. Rather than being tied to the nurses' station or the office, laptops and personal data assistants (PDAs) accompanied nurses to the bedside and the home. Knowledge resources such as MEDLINE became available at the point of care.¹⁴

To guide the further development of technology to support nursing practice, education, and research, the Kellogg Foundation-funded National Commission on Nursing Implementation Project, in collaboration with the American Nurses Association and the National League for Nursing, sponsored an invitational working

conference of nursing informatics leaders. The product, *Next Generation Nursing Information Systems: Essential Characteristics for Professional Practice*, described attributes that would support nursing care delivery and documentation, quality improvement, and nursing research.²⁹

When the American Medical Informatics Association was founded in 1990 through the merger of 3 existing informatics associations, the nurses who had been meeting annually at the Symposium on Computer Applications in Medical Care formed the Nursing Informatics Working Group (NI-WG), with Judy Ozbolt as its first chair. The NI-WG's clear rules of procedure, mechanism for the election of officers, and ambitious professional activities made it a congenial professional home for nurses in informatics and a model for AMIA's other working groups.³⁰ Nurses became interdisciplinary leaders in AMIA, chairing the scientific program committees for symposia, serving as officers and members of the board of directors, and leading committees.

Nurses were becoming increasingly visible in informatics roles, and in 1994 the American Nurses Association published the first versions of the *Scope of Nursing Informatics Practice* and the *Standards of Nursing Informatics Practice*. These have since been combined into a single document and updated twice (most recently in 2008).³¹ In 1995, the American Nurses Credentialing Center established basic certification in nursing informatics as an area of specialty practice. In 1996, James Turley, expanding on the Graves and Corcoran definition of nursing informatics, published a new model that outlined areas of research in the discipline.³²

With the growing sophistication of nursing informatics knowledge and technology, additional graduate programs were established at the University of Utah, the University of Colorado, Duke University, and elsewhere. Nancy Stagers, earning the first PhD in Nursing Informatics at the University of Maryland, launched a research program on nurse-computer interaction that continues today.³³ Linda Woolery (later Goodwin), combining her clinical expertise in labor and delivery with her informatics skills, began using data mining and machine learning to improve prediction of preterm birth.³⁴ With the rapid dissemination of information technology to consumers, Patricia Brennan saw the possibility of providing computer-based education and support to patients and caregivers in their homes. In a series of projects, she demonstrated that people could derive health benefits from computer-based interactions with one another and with nurses.^{35,36}

Other researchers continued to pursue Nightingale's and Werley's vision of capturing and using nursing data to improve the quality of care and control costs. The lack of standards for nursing language and data, however, still raised barriers.³⁷ Although the ANA Data-

base Steering Committee (subsequently renamed the Committee on Nursing Practice Information Infrastructure—CNPII) foresaw the development of a Unified Nursing Language System,³⁸ nursing languages continued to proliferate.

Seeking computable language to describe nursing in electronic record systems, Susan Grobe analyzed home care records and developed the Nursing Interventions Lexicon and Taxonomy, publishing the first report in 1990.³⁹ In 1991, Saba published the Home Health Care Classification (HHCC).⁴⁰ Based on a national sample of home health care patient records, the HHCC identified nursing diagnoses and interventions that predicted resource consumption.^{41,42} The HHCC was subsequently generalized to other clinical settings and renamed the Clinical Care Classification System.⁴³ The original language for the homecare population, the Omaha System, was adopted by numerous home care and community health nursing agencies across the nation.¹³ The Nursing Outcomes Classification (NOC) joined the NANDA and NIC classifications to provide a coordinated set of clinical languages.⁴⁴

In an effort to create a global consensus on nursing terminology, the International Council of Nurses (ICN) authorized 3 nurses—June Clark of the UK, Norma Lang of the USA, and Randy Mortensen of Denmark—to develop the International Classification of Nursing Practice (ICNP). (Today Amy Coenen of the USA directs the continuing development and translation of the ICNP).⁴⁵ Meanwhile, the College of American Pathologists established a workgroup to identify, define, and integrate nursing concepts into the Systematic Nomenclature of Medicine, SNOMED.⁴⁶

Faced with the bewildering array of choices and the licensing fees required for the use of NANDA, NIC, NOC, and SNOMED, many health care organizations adopting nursing information systems opted to use their own or vendor-provided, non-standard terms. This approach allowed entry of data via familiar terms, but because the terms were not consistent in definition or usage, investigators could not retrieve meaningful data to analyze for quality improvement or research.

During the 1990's, Suzanne Bakken Henry, Nicholas Hardiker, and a few other nurse informaticians were beginning to develop understanding of what would be required for nursing terminologies to be computable and semantically interoperable with one another and with other terminologies in biomedicine.^{47,48} In 1999, with support from the National Library of Medicine and vendor sponsors, Judy Ozbolt convened an invitational working conference of those nurse informaticians; developers of nursing languages; other experts on terminology and standards; and representatives of professional associations, the federal government, and the vendor community. The group concluded that the nursing languages recognized by the ANA's CNPII were potentially useful as interface languages in

information systems, but for computability and semantic interoperability, they would need to be mapped to a formal, concept-based reference terminology. The Unified Medical Language System (UMLS) and SNOMED CT were examples of imperfect, but evolving, reference terminologies that incorporated nursing concepts. The group agreed to continue meeting in a series of Nursing Terminology Summit Conferences to develop concept-oriented reference terminology models for nursing.⁴⁹

THE 2000'S

When Evelyn Hovenga of Australia, then the chair of the Nursing Informatics Special Interest Group (NI-SIG) in IMIA, learned of the work of the 1999 Terminology Summit Conference, she recognized that the standards development effort to which the group had committed needed to go forward as an officially sanctioned initiative to the International Standards Organization's Technical Committee 215 (ISO-TC 215). Hovenga enlisted the collaboration of Ozbolt and the Summit participants and secured sponsorship from IMIA and ICN. In 2000, the Nursing Terminology Summit participants collaborated with IMIA and ICN in drafting a proposal to ISO-TC 215 for a New Work Item. Christopher Chute, MD, DPH, a US representative to TC 215, submitted the proposal on behalf of nursing. Once approved, IMIA and ICN led an international initiative to create reference terminology models for nursing. Virginia Saba, who had succeeded Hovenga as chair of IMIA NI-SIG, chaired the Steering Committee, and Suzanne Bakken (formerly Henry) led the Technical Committee that would draft the models.

The 2000 Nursing Terminology Summit Conference brought together the leading developers of nursing terminology standards from Europe, North America, Latin America, Australia, and Asia. Discussion at the Summit enabled participants to resolve issues so that the IMIA-ICN work could advance to ISO a united, global standards development initiative for nursing terminology models. In 2003, ISO adopted the proposed models as standards.^{50,51} By the time of the tenth Nursing Terminology Summit Conference in 2008, the focus had shifted from developing standards to reviewing, revising, and implementing standards.

The ISO work and the Terminology Summit work contributed substantially to the integration of nursing concepts in SNOMED CT, and the nursing interface terminologies were mapped to concepts in SNOMED CT. In 2004, the National Library of Medicine licensed SNOMED CT for use by any healthcare organization in the United States and began to integrate SNOMED's reference terminology with the Unified Medical Language System.⁵² Subsequently, the College of American Pathologists surrendered its intellectual property rights in SNOMED, and in April 2007 the International Health Terminology Standards Development Organiza-

tion (IHTSDO), based in Copenhagen, took over responsibility for maintaining SNOMED as an international reference terminology standard.⁵³

Meanwhile, propelled by the Institute of Medicine's reports, *To Err is Human*² and *Crossing the Quality Chasm*,⁵⁴ a number of public and private efforts were raising public and political awareness of informatics as an essential technology for improving health care. In 2004, President George W. Bush called for every American to have an electronic health record by 2014 and signed Executive Order 13335, mandating the Secretary of Health and Human Services to establish an Office of the National Coordinator of Health Information Technology.^{55,56} In accordance with the Executive Order, Secretary Michael O. Leavitt established and personally chaired the American Health Information Community (AHIC), a group of national leaders from many fields charged with overseeing and expediting the creation of a national health information infrastructure.

Recognizing that the adoption of standards would be necessary to interoperability, AHIC designated 2 organizations to assure this outcome. The Health Information Technology Standards Panel (HITSP), created in cooperative partnership with the American National Standards Institute (ANSI), the official US representative to ISO, reviews candidate standards and recommends which ones the federal government should adopt to assure interoperability of health information transactions.⁵⁷ Standards adopted for use in Medicare and Medicaid transactions and in the healthcare information systems of the Veterans Health Administration and the Department of Defense become de facto standards for the private sector as well. The other organization, the Certification Commission for Healthcare Information Technology, is a private, not-for-profit organization that reviews hardware and software products and certifies them if they adhere to the adopted standards.⁵⁸ Nurses are well-represented in HITSP and CCHIT. The first of the nursing languages recommended for adoption was the Clinical Care Classification System.

Indeed, interdisciplinary collaboration at the Nursing Terminology Summit Conferences introduced a number of nurses to standards activities and organizations. One result has been nursing participation in, and ultimately leadership of, initiatives not only in ISO and IHTSDO, but also in other major standards developing organizations and initiatives. These include SNOMED, Health Level 7 (HL7)⁵⁹ and Logical Object Names, Identifiers, and Codes (LOINC),⁶⁰ as well as HITSP and CCHIT. Following leadership roles in the Terminology Summit, SNOMED, and HL7, Judith Warren became the first nurse appointed to the National Committee on Vital and Health Statistics.⁶¹

In 2008, nursing has the data and terminology tools to create "records fit for any purpose of comparison."¹ Many challenges remain, however. Nurses and administrators need education to appreciate the importance

and power of standardized language compared to more familiar colloquial terms. They must demand that vendors provide systems that use standardized language and that provide the functionality to aggregate and analyze data for timely feedback, decision support, quality improvement, and research. Clinical experts must work with terminology experts to develop computable, semantically interoperable standard language for those practice domains not adequately covered by existing standard languages. Researchers and developers must discover ways to use computable language and data to support nursing clinical and management decisions at the point of need. Nursing records must be integrated with other records to support communication and retrieval of critical information.

As many of the fundamental issues of nursing terminology and data standards moved into the mainstream of interdisciplinary development and implementation, nurse researchers continued to advance the science of informatics in other domains. A number of these researchers looked for ways that electronic tools could support nurses' traditional roles as patient and family educator, counselor, and advocate. As a logical continuation of the work she began in the 1990's, Patricia Brennan is now the national director of a Robert Wood Johnson Foundation-funded multi-site research program to develop innovative approaches to personal health records and tools for health management.⁶² Eun-Shim Nahm and colleagues are demonstrating the usability and efficacy of such tools in helping older people and their caregivers to manage personal and family health.⁶³ Cornelia Ruland explores decision support systems that engage the patient's preferences and autonomy.⁶⁴⁻⁶⁶

Nancy Staggers provides an example of a pioneer who continues to enrich the scholarship of nursing informatics. Her ongoing research in nurse-computer interactions provides insights into usability of systems in distracting, complex clinical environments.⁶⁷ Her proposed new definition of nursing informatics incorporates past definitions while better representing the depth and complexity of the discipline.⁶⁸ Finally, her research with Carole Gassert and Christine Curran on informatics competencies for all nurses, not only those practicing informatics,⁶⁹ is influencing curricula and accreditation standards for nursing education programs,⁷⁰ as well as the revised *Scope and Standards of Nursing Informatics Practice*.³¹

EMERGING DEVELOPMENTS

When President George W. Bush declared "the decade of health information technology" in 2004, the evolution of nursing informatics accelerated. Then a member of the Board of Directors of the American Medical Informatics Association (AMIA), Connie Delaney recognized that a great many nursing organizations had activities or divisions concerned with informatics. So

that nursing informatics could speak with one strong voice in this time of rapid change, Delaney worked with Joyce Sensmeier at the Health Information Management and Systems Society (HIMSS) and leaders of the other organizations to forge the Alliance for Nursing Informatics (ANI). Sponsored by AMIA and HIMSS, ANI provides linkages among > 25 member organizations and a united voice in policy issues, representing > 3000 nurses.⁷¹

As ANI was coalescing, Angela McBride was completing a year as a Scholar in Residence at the Institute of Medicine. A major product of her work was "Nursing and the Informatics Revolution," a description of the changes in health care being mediated by informatics, nursing's readiness to participate in the revolution, and challenges to overcome.⁷² Coming as it did from a distinguished nurse educator, researcher, and practitioner not previously identified with nursing informatics, the paper made a strong impact. McBride and Marion Ball, a long-time advocate of nursing informatics (although not a nurse), collaborated with ANI in organizing a number of colleagues from academia and informatics practice to create the TIGER (Technology Informatics Guiding Educational Reform) initiative. At an invitational conference in 2005, the group developed a common vision of an informatics-enabled future for nursing and secured commitments from nursing leaders to take specific actions to realize that future. The TIGER work continues through collaborative teams, with ANI as the enabling organization.⁷¹

Distinguishing the informatics competencies required for all nurses from those required for informatics nurse practitioners and innovators, as the Staggers, Gassert, and Curran research did,⁶⁹ is evidence of the disciplinary maturation of nursing informatics. Now Judith Effken, chair of the AMIA NI-WG,³⁰ is collaborating with Carol Bickford of the American Nurses Association to seek an occupational designation for informatics nurses in the North American Industry Code. When granted, this code will provide recognition in the workplace and in employment statistics of the unique skills and contributions of informatics nurses.

While nursing informatics leaders work to transform nursing education and practice, nursing informatics scientists are creating the knowledge and tools that will enable the transformation. As research in nursing terminology and knowledge representation moves from creation to implementation and use, other domains of research reflect the maturation of nursing informatics as a science.

From the microcosm of genetics and genomics to the macrocosm of public health, nurses are using knowledge discovery methods to detect and prevent risks to health. At both the personal and the systems level, discovery of knowledge brings responsibility to act upon the knowledge. Change is difficult, however, and the ramifications are often surprising. Nurses are study-

ing systems and organizations from an informatics perspective to discover how to deliver care and support decisions more effectively and safely, with better outcomes for all constituencies. Informatics tools can support the translation of knowledge into practice, but changing the behavior of people, organizations, and systems requires collaboration across a range of disciplines.

Collaboration for change is as essential in education as it is in nursing practice. Nurses in the 21st century not only have access to new information resources, they also have responsibility to use them wisely. To integrate these resources into the cognitive, psychomotor, and organizational processes of professional practice, nurse

educators face the challenges of transforming their curricula and their teaching methods. Tomorrow's nurses cannot prepare for the complex demands of 21st century health care merely by learning technological skills. They must acquire the wisdom to use data, information, knowledge, and the technologies that support them to transform nursing practice and health care systems. Only then will these new assets "enable us to save life and suffering, and to improve the treatment and management of the sick"

REFERENCES

Available in the online version of this article at the *Nursing Outlook* Website: www.nursingoutlook.org.

REFERENCES

1. Nightingale F. Notes on Hospitals, 3rd Edition, enlarged and for the most part rewritten. London: Longman, Green, Longman, Roberts, and Green, 1863. p. 175-6.
2. Institute of Medicine, Committee on Quality of Health Care in America. To err is human: Building a safer health system. Washington, DC: National Academy Press, 2000.
3. Werley HH, Lang NM. Preface. In: Werley HH, Lang NM, editors. Identification of the Nursing Minimum Data Set. New York, NY: Springer; 1987. p. xix-xxii.
4. American Nurses' Association, Committee on Research and Studies. ANA blueprint for research in nursing. *Am J Nurs* 1962;62:60-71.
5. Cornell SA, Bush F. Systems approach to nursing care plans. *Am J Nurs* 1971;71:1376-8.
6. Wesseling E. Automating the nursing history and care plan. *J Nurs Admin* 1972;XX:34-8.
7. Beggs S, Vallbona C, Spencer WA, Jacobs FM, Baker RL. Evaluation of a system for on-line computer scheduling of patient-care activities. *Computers and Biomed Res* 1971;4: 634-54.
8. Cook M, McDowell W. Changing to an automated information system. *Am J Nurs* 1975;75:46-51.
9. Gall JE, Norwood DD, Cook M, et al. Demonstration and evaluation of a total hospital information system. NCHSR Research Summary Series [Publication no. (HRA) 77-3188]. U.S. Department of Health, Education, and Welfare. Springfield, VA: National Technical Information Service, 1977.
10. Mayers M. Standard Nursing Care Plans. Palo Alto, CA; K.P. Co. Medical Systems; 1974.
11. National Center for Health Services Research. Computer Applications in Health Care. NCHSR, Research Report Series [Pub. No. 80-2151]. U.S. Department of Health and Human Services, Hyattsville, MD, 1980.
12. Simmons DA. Nurse planning information systems: A classification scheme for client problems in community health nursing. Health Professions Administration [Pub. No. HPA 80-16]. U.S. Department of Health and Human Services. Springfield, VA: National Technical Information Service, 1980.
13. Martin KS. The Omaha System: A key to practice, documentation, and information management. (2nd ed). St. Louis, MO: Elsevier; 2005.
14. Saba VK, McCormick AK. Essentials of Computers for Nurses. (2nd edition). New York, NY: McGraw-Hill; 1996.
15. Souder DE, Zielstorff RD, Barnett GO. Experience with an automated medication system. In: Ducrot et al, editors. Computer Aid to Drug Therapy and to Drug Monitoring. New York, NY: North-Holland Publishing Co; 1978. p. 291-301.
16. Zielstorff RD, Roglieri JL, Marble KD, Poitras JW, Van Deusen F, Follayttar SM, et al. Experience with a computer-based medical record for nurse practitioners in ambulatory care. *Comput Biomed Res* 1977;10:61-74.
17. Zielstorff RD, Barnett GO, Jette AM, Piggins JL, Weidman-Dahl F, Webster S, et al. A COSTAR-based multidisciplinary record system for long-term care practice and research. In: Salamon R, Blum B, Jorgensen M, editors. Medinfo '86. North Holland: Elsevier Science Publishers BV; 1986. p. 844-8.
18. Zielstorff RD, editor. Computers in Nursing. Rockville, MD: Aspen Systems Corp; 1980.
19. Lagina SM. A computer program to diagnose anxiety levels. *Nurs Res* 1971;20:484-92.
20. Ozbolt Goodwin J, Edwards BS. Developing a computer program to assist the nursing process: Phase I—from systems analysis to an expandable program. *Nurs Res* 1975: 24299-305.
21. Gebbie KM, editor. Summary of the Second National Conference: Classification of Nursing Diagnoses. St. Louis, MO: National Group for Classification of Nursing Diagnoses; 1975.
22. Gordon M. Nursing diagnoses and the diagnostic process. *Am J Nurs* 1976;76:1298-1300.
23. Cimino JJ. Desiderata for controlled medical vocabularies in the 21st century. *Meth Info Med* 1998;37:394-403.
24. Werley HH, Grier MR. Preface. In: Werley HH, Grier MR, editors. Nursing information systems. New York, NY: Springer Publishing Company; 1981p. 9.
25. Werley HH, Lang NM, editors. Identification of the nursing minimum data set. New York, NY: Springer; 1987.
26. Bulechek GM, Butcher HK, Dochterman JMcC. The Nursing Interventions Classification (NIC). (5th ed). Elsevier, 2008. (First edition published 1984).
27. Graves JR, Corcoran S. The study of nursing informatics. *Image: J Nurs Scholarsh* 1989;21:227-31.
28. Ozbolt JG (Chair). Nursing informatics: Enhancing patient care. Bethesda, MD: National Center for Nursing Research, NIH, U.S. Department of Health and Human Services; 1993.
29. Zielstorff RD, Hudgings CI, Grobe SJ, The National Commission on Nursing Implementation Project (NCNIP) Task Force on Nursing Information Systems. Next-generation Nursing Information Systems: Essential Characteristics for Professional Practice. Washington, DC: American Nurses Publishing; 1993.
30. American Medical Informatics Association, Nursing Informatics Working Group. Available at: <http://www.amia.org/mbrcenter/wg/ni/>. Accessed on February 4, 2007.
31. American Nurses Association. Nursing informatics: Scope and Standards of Practice. Silver Spring, MD: American Nurses Publishing; 2008.
32. Turley JP. Toward a model for nursing informatics. *J Nurs Scholarsh* 1996;28:309-13.
33. Staggers N, Mills ME. Nurse-computer interaction: Staff performance outcomes. *Nurs Res* 1994;43:144-50.
34. Woolery LK, Grzymala-Busse JW. Machine learning for an expert system to predict preterm birth risk. *J Am Med Inform Assoc* 1994;1:439-46.
35. Brennan PF, Moore SM, Smythe KA. ComputerLink: Electronic support for the home caregiver. *Adv Nurs Sci* 1991; 13:14-27.
36. Brennan PF, Moore SM, Smyth KA. The effects of a special computer network on caregivers of persons with Alzheimer's disease. *Nurs Res* 1995;44:166-72.
37. Henry SB, Holzemer WL, Tallberg M, Grobe SJ. (Eds.) Informatics: The infrastructure for quality assessment and improvement in nursing. Proceedings of the Fifth International Nursing Informatics Symposium Post-Conference. Austin, TX, June 24-25, 1994. UC Nursing Press, 1995.
38. McCormick KA, Lang N, Zielstorff R, Milholland DK, Saba V, Jacox A. Toward standard classification schemes for nursing language: Recommendations of the American

- Nurses Association Steering Committee on Databases to Support Clinical Nursing Practice. *J Am Med Inform Assoc* 1994;1:421-7.
39. Grobe SJ. Nursing intervention language and taxonomy study: Language and classification methods. *Adv Nurs Sci* 1990;13:22-33.
 40. Saba VK, O'Hare P, Zukerman AE, Boondas J, Levine E, Outway D. A nursing intervention taxonomy for home health care. *Nurs Health Care* 1001;12:296-99.
 41. Saba VK. The classification of home health care nursing: Diagnoses and interventions. *Caring* 1992:50-7.
 42. Saba VK. Home health care classification. *Caring* 1992; 58-60.
 43. Saba VK. Clinical Care Classification (CCC) System Manual: A Guide to Nursing Documentation. New York, NY: McGraw-Hill; 2007.
 44. Moorhead S, Johnson M, Maas M, Swanson E. Nursing Outcomes Classification (NOC). (4th ed). Philadelphia, PA: Elsevier, 2008.
 45. International Council of Nurses. International Classification Of Nursing Practice (ICNP) Fact Sheet. Available at: http://www.icn.ch/matters_ICNP.htm. Accessed on January 16, 2008.
 46. Warren JJ, Casey A, Konicek D, Lundberg C, Correia C, Zingo C. Where is the nursing in SNOMED CT(R)? CTGFN has the answer! *Proc AMIA Sym* 2003, 1047.
 47. Henry SB, Holzemer WL, Reilly CA, Campbell K. Terms used by nurses to describe patient problems: Can SNOMED III represent nursing concepts in the patient record? *J Am Med Inform Assoc* 1994;1:61-74.
 48. Henry SB, Mead CN. Nursing classification systems: Necessary but not sufficient for representing "What nurses do" for inclusion in computer-based patient record systems. *J Am Med Inform Assoc* 1997;4:222-32.
 49. Ozbolt J. The Nursing Terminology Summit Conferences: A case study of successful collaboration for change. *J Biomed Inform* 2003;36:362-74.
 50. ISO 18104: 2003. Available at: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=33309. Accessed on January 16, 2008.
 51. Saba VK, Coenen A, McCormick K. (2003, September). Nursing language-terminology models for nurses. *ISO Bulletin* 2003;September:16-8.
 52. National Library of Medicine, 2008. Available at: http://www.nlm.nih.gov/research/umls/Snomed/snomed_main.html. Accessed on January 16, 2008.
 53. International Health Terminology Standards Developing Organization. Available at: <http://www.ihtsdo.org>. Accessed on February 2, 2008.
 54. Institute of Medicine, Committee on Quality of Health Care in America. Crossing the quality chasm: A new health system for the 21st Century. Washington, DC: National Academy Press; 2001.
 55. Bush GW. Executive Order: Incentives for the Use of Health Information Technology and Establishing the Position of the National Health Information Technology Coordinator. Washington, DC: The White House; 2004.
 56. U. S. Department of Health and Human Services. Health Information Technology. Available at: <http://www.hhs.gov/healthit/>. Accessed May 7, 2008.
 57. Health Information Technology and Standards Panel. Available at: <http://www.hitsp.org>. Accessed May 7, 2008.
 58. Certification Commission for Healthcare Information Technology. Available at: <http://www.cchit.org>. Accessed May 7, 2008.
 59. Health Level 7. Available at: <http://www.hl7.org>. Accessed May 7, 2008.
 60. Logical Observation Identifiers Names and Codes. Available at: <http://loinc.org>. Accessed May 7, 2008.
 61. U. S. Department of Health and Human Services. National Committee on Vital and Health Statistics. Available at: <http://ncvhs.hhs.gov>. Accessed May 7, 2008.
 62. Moen A, Brennan PF. Health@Home: The work of health information management in the household (HIMH): Implications for consumer health informatics (CHI) innovations. *J Am Med Inform Assoc* 2005;12:648-56.
 63. Nahm ES, Preece J, Resnick B, Mills ME. Usability of health web sites for older adults: A preliminary study. *Comput Inform Nurs* 2004;22:326-34.
 64. Ruland CM. Decision support for patient preference-based care planning. *J Am Med Inform Assoc* 1999;6:304-12.
 65. Ruland CM, Bakken S. Developing, implementing, and evaluating decision support systems for shared decision making in patient care: A conceptual model and case illustration. *J Biomed Inform* 2002;35:313-21.
 66. Ruland CM. Improving patient safety through informatics tools for shared decision making and risk communication. *Internat J of Med Inform* 2003;73:551-7.
 67. Staggers N, Kobus D. Comparing response time, errors, and satisfaction between text-based and graphical user interfaces during nursing order tasks. *J Am Med Inform Assoc* 2000; 7:164-76.
 68. Staggers N, Thompson CB. The evolution of definitions for nursing informatics: A critical analysis and revised definition. *J Am Med Inform Assoc* 2002;9:255-61.
 69. Staggers N, Gassert CA, Curran C. A Delphi study to determine informatics competencies for nurses at four levels of practice. *Nurs Res* 2002;51:383-90.
 70. American Association of Colleges and Nursing. Available at: <http://www.aacn.nche.edu>. Accessed May 7, 2008.
 71. Alliance for Nursing Informatics. Available at: <http://www.allianceni.org/about.asp>. Accessed on January 21, 2008.
 72. McBride AA. Nursing and the informatics revolution. *Nurs Outlook* 2005;53:183-91.