

Nursing Informatics: Decades of Contribution to Health Informatics

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Objectives: In this paper we present a contemporary understanding of “nursing informatics” and relate it to applications in three specific contexts, hospitals, community health, and home dwelling, to illustrate achievements that contribute to the overall schema of health informatics. **Methods:** We identified literature through database searches in MEDLINE, EMBASE, CINAHL, and the Cochrane Library. Database searching was complemented by one author search and hand searches in six relevant journals. The literature review helped in conceptual clarification and elaborate on use that are supported by applications in different settings. **Results:** Conceptual clarification of nursing data, information and knowledge has been expanded to include wisdom. Information systems and support for nursing practice benefits from conceptual clarification of nursing data, information, knowledge, and wisdom. We introduce three examples of information systems and point out core issues for information integration and practice development. **Conclusions:** Exploring interplays of data, information, knowledge, and wisdom, nursing informatics takes a practice turn, accommodating to processes of application design and deployment for purposeful use by nurses in different settings. Collaborative efforts will be key to further achievements that support task shifting, mobility, and ubiquitous health care.

Keywords: Nursing Informatics, Knowledge, Health Information Systems, Personal Health Records, eHealth

I. Introduction

The introduction and use of new technology to support nurses in their care for patients always leads to change and the development of new service repertoires [1]. Changes and

innovations contribute to specialization of health care, nursing care, and treatment, and should stimulate discussions of how to harness opportunities, handle dilemmas, and prevent harm from automation during such transitional periods. The purposeful use of digital tools is one of the key strategies to meet foreseen health care challenges locally and globally. Health informatics includes contributions from several areas, e.g., nursing informatics, medical informatics, clinical informatics, dental informatics, etc. These terms are used interchangeably with or are gradually being substituted by the term eHealth [2]. Achievements in biomedical and health informatics are significant contributors to increasingly advanced diagnostic processes, personalized treatment, and advanced health management regimes to control chronic conditions. They also contribute to efforts at prevention, early intervention, or task shifting to meet requirements for independence and aging in place.

Over time, several attempts have been made to describe

Submitted: May 29, 2013

Accepted: June 24, 2013

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the different subdomains within the interdisciplinary field of health informatics. Health informatics is an umbrella term for a field of study that combines domain knowledge from the health sciences, e.g., medicine, nursing, and pharmacy, with insights from information and computer sciences. Those pursuing a health informatics career are typically cross-trained to skillfully combine domain expertise and insights from information and computer sciences [3]. For this article, we will take health informatics as a point of departure, to zoom in on contributions by *nursing informatics*. We will present a conceptual clarification of the field and introduce Electronic Health Records (EHR), Personal Health Records (PHR), and smart, assistive tools as examples of information systems used in hospitals, community care, and home dwelling.

II. Methods

To obtain an overview of more of the field, we searched different electronic databases, complemented by an author search and a hand search in especially relevant journals [4], in order to complement the practical examples. We searched MEDLINE, EMBASE, CINAHL, and the Cochrane Library using the search terms listed in Table 1.

The terms within each of the columns, “Focus” and “Setting,” were connected using the logical term, “OR.” The terms in the column, “Point of view,” however, were separated into different sections by the horizontal lines in the column, and the terms within each section were then connected with “OR.” Then the terms in “Focus” and “Setting” were connected to each of the sections in “Point of view” with the operator, “AND,” so that the focus and setting relevant for this

review were searched for from different points of view. The hand-searched journals found to be especially relevant were the *International Journal of Medical Informatics*, *Journal of American Medical Informatics Association*, *Methods of Medical Informatics*, *International Journal of Knowledge* (former *International Journal of Nursing Terminologies and Classifications*), *CIN: Computers, Informatics, Nursing* (former *Computers in Nursing*), and *Journal of Medicine and Internet Research*.

III. Results

The core issues in health informatics, where nursing informatics provides important contributions, are illustrated by the plethora of questions relating to automation. Since computer technology was first introduced in health care, grand challenges were found in the convergence of practicalities, usability, caring discipline characteristics, and automating devices. Early on, nurses were challenged to ask “meaningful questions” to maximize and take advantage of the emerging opportunities to benefit patient care [5]. The term “nursing informatics” was proposed in 1976, when Scholes and Barber [6] elaborated on the potentialities of computer technology for a practice discipline like nursing, specifically discussing contributions to service, education, and research. Since then, nursing informatics as a field of inquiry has been established as one of the cornerstones of the interdisciplinary field of health informatics. Nursing informatics is also a distinct specialty within nursing, distinguished from other specialties by the focus on *information of nursing*. Drawing from multiple fields, nursing informatics has contributed significantly to clarifying the components neces-

Table 1. Search terms

Focus	Point of view	Setting
Nursing informatics	Definition	Hospital health
Health informatics	Conceptualization	Primary healthcare
Clinical informatics	Terminology/nomenclature	Community health
Consumer health informatics	Concept	Home
eHealth/Electronic health	Concept representation	
mHealth/Mobile health	Semantic	
uHealth/Ubiquitous health	Syntax	
u-healthcare	Workflow	
Telemedicine care	Clinical information system	
Big data	Health information technology	
	Provider order entry	
	Patient portals	
	Avatar	
	User-centered design	

sary for the representation of nursing practice: assessment, problems, interventions and outcomes, and the standards and strategies for achieving efficient information exchange. Nursing informatics also synthesizes resources for evidence-based practice, patient safety, and professional development [7-9]. We look further into these contributions in terms of selected *conceptual issues* such as content representation, standards development, decision support, and knowledge resources. We also examine *application oriented aspects* such as opportunities following design, deployment, or change in the interest of practice improvements. We will use examples of information systems in hospitals, community health, and the home dwelling.

1. Conceptual Understanding of Nursing Informatics

The seminal paper by Graves and Corcoran [10] in 1989 set the stage for conceptualizing the specialty of nursing informatics. They defined nursing informatics as “*a combination of computer science, information science and nursing science designed to assist in the management and processing of nursing data, information and knowledge to support the practice of nursing and the delivery of care*”. Here they draw attention to the information of nursing, elaborating data, information, and knowledge as the foundational components for collection, processing, or manipulation by technological tools. Although there are different perspectives on the relations between data, information, and knowledge (i.e., portraying linear, progressing complexity or as mutually constituted, accumulated elements), the components can be understood as follows. *Data* is “raw facts,” that is, the basic elements (atomic structure) or uninterpreted building blocks for composition to information or knowledge. *Information* is combined or structured data interpreted in different contexts or situations. *Knowledge* is data or information synthesized by formulas, heuristic strategies, or formally delineated relationships [8,10]. These interrelated elements of data, information, and knowledge point out important attributes of evidence in nursing, but they also differentiate foci within nursing informatics. The establishment of comprehensive nursing vocabularies with interface and reference properties, e.g., enumerative classification systems, combinatorial terminologies, or reference terminologies is an example of the important efforts to articulate, represent, and sort nursing *data* [11,12]. Combining data into a structure gives the meaning and value of these raw facts and basic expressions. Therefore, the structuring of nursing documentation and the developing of care protocols, care maps, or clinical pathways are examples of organizing, filtering, interpreting, and clarifying nursing *information* [13-15]. Examples of efforts to outline nursing *knowledge* include

modeling the expert nurse’s decision-making to provide computerized decision support to enhance clinical judgment [7] or elaborating on the knowledge resources at play to construct standards, common guidelines, and procedures [16]. Development of and access to information and knowledge are core requisites for supporting experiential and evidence-based decision-making, continuity of care, and patient safety. In sum, considerable achievements have been gained in terms of expressions for nursing assessment, nursing judgments, nursing interventions, and patient outcomes that are sensitive to nursing care. Substantial resources in informatics are currently committed to establishing comprehensive and formalized terminologies to represent clinical practice and standards for information exchange. This allows relationships among various types of data to be examined or transformed through more automated processes. This examination and transformation is surrounded with unresolved challenges due to the situated nature of patient care, the variation in personal health needs, and evolving opportunities resulting from new achievements and new tools.

Over time, scholars have suggested, discussed, and added functional elements that contribute to the collective effort to elaborate and expand the understanding, concepts, tools, and structures available to nursing informatics and nursing. These ideas include enhancing the patient’s role, emphasizing the nurse’s role as information integrator, developing sound collaborative relationships between providers or between providers, technologies, and specific contexts of decision-making, and including true interdisciplinary issues for patient safety and evidence-based practice [9]. A significant addition to the conceptual understanding of nursing informatics came more recently when Matney et al. [17] suggested the inclusion of *wisdom*, complementing the foundational concepts of data, information, and knowledge. Wisdom is understood as the “*appropriate use of knowledge to manage and solve human problems*” [17]. This is of great significance, important in understanding the variations in clinical processes in sufficient detail and in acknowledging previous experiences. In reality, Matney et al. [17] challenge us to acknowledge the situatedness embedded in nurses work, and to embrace accumulated clinical expertise. These are resources for skillful, competent clinical judgment, and they involve the contextual and intertwined nature of data, information, and knowledge.

2. Application and Use of Informatics in Health Care

Achievements in nursing informatics have inspired the systematization and formalization of information where data, structured information, and articulated knowledge

are important building blocks for the development of IT-based applications. Most attention and in-depth study has been directed to describing information used in clinicians' judgments and modeling prototype applications for management that are decision-supportive. The studies also strive to provide the best evidence at the point of care to improve decision-making. So far, feasible practice models giving new tools for information handling have received little attention, and reported studies are often examples of workflow failure [18] or unintended consequences [19].

When we zoom in on applications using achievements in health informatics, there is also a plethora of tools, devices, and applications aiming to support the management of data, information, and knowledge related to health and wellbeing. The following types of applications add new opportunities and challenges to the field:

1) EHR is a repository maintained by health facilities, with a set of functionalities and services, that accumulates the health providers' assessments, actions, and evaluations of a person's clinical problems as separate episodes or over the life trajectory.

2) PHR is a repository maintained by the consumer, with a set of personal observations, information from health providers, and relevant information resources. The scope and comprehensiveness of the accumulating content in a PHR depends on the individual's effort.

3) Smart assistive tools include stand-alone applications and tools for personal self-care activities for everyday, everywhere use. Passive, environmental monitoring by sensors also supports the individual's personal health information management and safety.

These types of applications present novel opportunities and important challenges to our field, but their interrelationships and how together they may contribute to efficient information are not fully understood [20-22].

The Problem-Oriented Medical Record [23,24] was among the first influential published implementation experiences where informatics supported health information management and health care processes. The core idea was to embed an information model that de facto restructured clinical documentation in the EHR, using a problem-oriented approach in an attempt to reengineer documentation processes. The systematization of information elements, charted according to predefined templates or as narrative texts, most often follows the problem-oriented information model rather than models that deal with body systems, basic needs, or functional status, to represent nursing practice in an EHR. The "stickiness" of the problem-oriented structure for information models is seen globally, reflected as the information

model in the globally diffused nursing process, suggesting structures for clinical documentation of nursing care [13]. The same information model is seen as a dimension of nurses' work currently supported by emerging nursing vocabularies [11] and as the commonly used structure for health care knowledge representations, as a resource for the design, implementation, and evaluation of health information systems, and as an inspiration for practice changes following the deployment of health information systems [25].

Core features of nurses' work are teamwork, collaboration, and mobility. Nurses meet and interact with patients and their families in a variety of settings to contribute to prevention, early intervention, maintenance, or problem solving. Nurses typically care for many patients, and in a team, they assume key roles in coordinating patient care and treatment in collaboration with other providers [26]. Nurses collect a lot of data, and they access evidence at the nurses' station, at the bedside, in a person's home, or in an office. Incorporating contextual and environmental cues is crucial. These elements exemplify specific features of nurses' work and of their workflow. Lack of appropriate access to evidence at the point of need is a challenge for continuity of care and patient safety. Lack of aggregate information for reporting and benchmarking has so far been detrimental to nurses' adoption of new technological tools.

Professional collaboration can be supported by access to and/or contribution to the accumulating body of a person's specific health information in the EHRs. The EHR offers an interesting collection of quantitative data (e.g., vital signs or lab values), qualitative data (e.g., patient narratives or evaluation of care efforts), and transactional data (e.g., performed tests or delivered medications) [27]. More recent analytic techniques and approaches to the analysis of large amounts of data, or "Big Data," open up new ways of providing evidence to support knowledge development, decision-making, and interdisciplinary collaboration. Using information in the EHR means that the aggregation of authentic, real-time patient data offers opportunities for early intervention to prevent health problems or to manage existing conditions [28]. There are still unresolved issues of a professional, legal, and ethical nature with the new approaches to knowledge generation and to more information sharing within and across settings and levels of care [29].

As more health care activities migrate from hospitals to community care, the plethora of tools and functionalities follows. More work is needed to understand how better to integrate this information into the existing informatics infrastructure and into clinicians' suit of tools. Exciting opportunities for active collaboration with the patient and his or her

family can be further developed through skillful use of EHRs in combination with the PHR. A PHR contains information chosen, collected, and maintained primarily by the patient or a trusted family member. We know that people make tradeoffs between types of health information and health concerns as they use sophisticated and robust health information management strategies [30]. Therefore, information kept in the PHR will vary with the health concern and interest of the person keeping it.

A PHR can be a stand-alone application set up and maintained at the discretion of the person keeping it. More common is some connection to organized health care services. Depending on institutional and organizational arrangements and provision of services, persons using such a PHR can access parts of their EHR securely and remotely, some can take advantage of secure mail for online interactions with the health providers as well for accessing relevant health information [20,31]. In addition, the PHR carries the potential to be an even more used and valued resource for accumulating health information and supporting health information management as care activities increasingly shift to focus on prevention and early intervention and actively include the extensive self-care efforts of the citizens themselves. As such, a PHR can be an important resource for nurses if the recipients of nursing care choose to grant access to their caregivers. To be even more valuable for multiple users and uses, practical ways of capitalizing on benefits from the explication, systematization, and formalization of data, information, and knowledge can help us move forward. We believe that attention to wisdom and acknowledgment of the situational dimensions and specifics in nurses' interactions with their patients will open up new beneficial, collaborative relationships and further achievements.

New areas of application of health informatics can be found in the use of the growing suite of tools for ambient assisted living and smart houses and in the new potentialities for generating practice-based evidence using "Big Data" analytic techniques. New tools are increasingly used for personal monitoring and self-care activities, and we see expanding opportunities in applications labeled under the umbrella of mHealth or uHealth. These applications range from support for collecting personal observations, e.g., vital signs and observations of daily living [32], to support in collecting data from passive, environmental monitoring, e.g., use of space [33] or global positioning system for outside positioning [34], to the use of available tools to maintain independent living, e.g., tablets and smartphones for information access and new modes of participation [35]. These are novel opportunities to support the individual's personal health information man-

agement and safety requirements to allow him or her to remain at the preferred home dwelling as long as possible. Unfortunately, many of these tools "live a life of their own," that is, they are not well integrated to existing health informatics suites of tools [36]. Applying techniques developed for "Big Data" to accumulate clinical information from different sources and in a variety of formats provides opportunities for the active use of authentic, real-time patient data in developing health care and practice changes that embrace new and novel opportunities for analysis of clinical information. Among the future challenges are questions of how to incorporate these new opportunities to present sound, innovative care repertoires. It remains to be explored how such analytic techniques, applied to the plethora of available information, can add to knowledge and wisdom, and what future innovative practice models will be suggested. More research will also be appreciated to understand how to incorporate data from remote monitors in decision-making and clinical judgments without familiar, observational data to help in the interpretation of the discrete data.

IV. Conclusion

Critical issues addressed by nursing informatics are *data*, *information*, and *knowledge* complemented by *wisdom*. These contribute to conceptual clarifications helping to depict clinical processes in sufficient detail to support clinical judgments and to streamline nursing representations. The design and deployment of IT applications in health care are examples of achievements where information handling and new modes of care delivery call for renewed attention to organizational issues to ensure feasible and innovative *practice models*. As we move forward, nurses and other health providers will be challenged and invited to participate in processes to explore the use of clinical information systems in new ways and for new purposes. Mobility, new members of care teams, new analytic techniques, and more modalities are key issues. Keeping up a commitment to develop and implement tools that are supportive of nurses' and other health providers' work in collaboration with patients and their families calls for scrutiny and further elaborations of ease of use and digital literacy for all who are mindful of previous experience with the technology and with community uptake.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

This work was supported by “Evidence-based practice; knowledge resources and competency development,” Startup grant, Faculty of Medicine, University of Oslo, Oslo, Norway (Professor Anne Moen, grantee).

References

- Sandelowski M. Troubling distinctions: a semiotics of the nursing/technology relationship. *Nurs Inq* 1999;6(3):198-207.
- Moen A, Hackl WO, Hofdijk J, Van Gemert-Pijnen L, Ammenwerth E, Nykanen P, et al. eHealth in Europe: status and challenges. *Eur J Biomed Inform* 2012;8(1):en2-7.
- Friedman CP. What informatics is and isn't. *J Am Med Inform Assoc* 2013;20(2):224-6.
- Fink A. Conducting research literature reviews: from the internet to paper. 3rd ed. Thousand Oaks (CA): SAGE Publications; 2010.
- American Nurses Association. Technical innovations in health care: nursing implications. New York (NY): American Nurses Association; 1962.
- Scholes M, Barber B. The role of computers in nursing. *Nurs Mirror Midwives J* 1976;143(13):46-8.
- Henry SB. Nursing informatics: state of the science. *J Adv Nurs* 1995;22(6):1182-92.
- Staggers N, Thompson CB. The evolution of definitions for nursing informatics: a critical analysis and revised definition. *J Am Med Inform Assoc* 2002;9(3):255-61.
- Bakken S, Stone PW, Larson EL. A nursing informatics research agenda for 2008-18: contextual influences and key components. *Nurs Outlook* 2008;56(5):206-214.e3.
- Graves JR, Corcoran S. The study of nursing informatics. *Image J Nurs Sch* 1989;21(4):227-31.
- Coenen A, Marin HF, Park HA, Bakken S. Collaborative efforts for representing nursing concepts in computer-based systems: international perspectives. *J Am Med Inform Assoc* 2001;8(3):202-11.
- Park H, Hardiker NR. Clinical terminologies: a solution for semantic interoperability. *J Korean Soc Med Inform* 2009;15(1):1-11.
- Ehrenberg A, Ehnfors M, Thorell-Ekstrand I. Nursing documentation in patient records: experience of the use of the VIPS model. *J Adv Nurs* 1996;24(4):853-67.
- Moen A, Helleso R, Berge A. Nurses' record keeping, documentation and information handling. Oslo, Norway: Akribes; 2008.
- Moen A, Wibe T, Vedal T, Edwin E. Transition to the integrated HER: impact on nursing documentation in Norway. In: Weaver C, Delaney C, Weber P, Carr R, editors. *Nursing and informatics for the 21st century an international look at practice, trends and the future*. Chicago (IL): HIMSS; 2006. p. 388-92.
- Nes S, Moen A. Constructing standards: a study of nurses negotiating with multiple modes of knowledge. *J Workplace Learn* 2010;22(6):376-93.
- Matney S, Brewster PJ, Sward KA, Cloyes KG, Staggers N. Philosophical approaches to the nursing informatics data-information-knowledge-wisdom framework. *ANS Adv Nurs Sci* 2011;34(1):6-18.
- Fernandopulle R, Patel N. How the electronic health record did not measure up to the demands of our medical home practice. *Health Aff (Millwood)* 2010;29(4):622-8.
- Ash JS, Sittig DF, Poon EG, Guappone K, Campbell E, Dykstra RH, et al. The extent and importance of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc* 2007;14(4):415-23.
- Brennan PF, Downs S, Casper G. Project HealthDesign: rethinking the power and potential of personal health records. *J Biomed Inform* 2010;43(5 Suppl):S3-5.
- Hynes DM. Health information technology in VA quality improvement research overview. *Med Care* 2013;51(3 Suppl 1):S4-5.
- Luo G, Tang C, Thomas SB. Intelligent personal health record: experience and open issues. *J Med Syst* 2012;36(4):2111-28.
- Weed LL. Medical records that guide and teach. *N Engl J Med* 1968;278(11):593-600.
- Weed LL. Medical records that guide and teach. *N Engl J Med* 1968;278(12):652-7 concl.
- Haux R. Medical informatics: past, present, future. *Int J Med Inform* 2010;79(9):599-610.
- Moen A. Nursing leadership when an electronic patient record system is introduced in Norwegian hospitals [dissertation]. Oslo, Norway: University of Oslo; 2002.
- Murdoch TB, Detsky AS. The inevitable application of big data to health care. *JAMA* 2013;309(13):1351-2.
- Gardner E. The HIT approach to big data. *Health Data Manag* 2013;21(3):34, 36, 38 passim.
- Lyngstad M, Melby L, Grimsmo A, Helleso R. Toward increased patient safety? Electronic communication of medication information between nurses in home health care and general practitioners. *Home Health Care Manage Pract* Forthcoming 2013.
- 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(6):648-56.
31. Archer N, Fevrier-Thomas U, Lokker C, McKibbin KA, Straus SE. Personal health records: a scoping review. *J Am Med Inform Assoc* 2011;18(4):515-22.
 32. Backonja U, Kim K, Casper GR, Patton T, Ramly E, Brennan PF. Observations of daily living: putting the “personal” in personal health records. In: Proceedings of the 11th International Congress on Nursing Informatics; 2012 Jun 23-27; Montreal, Canada.
 33. Alexander GL, Wakefield BJ, Rantz M, Skubic M, Aud MA, Erdelez S, et al. Passive sensor technology interface to assess elder activity in independent living. *Nurs Res* 2011;60(5):318-25.
 34. Shaw NT. Geographical information systems and health: current state and future directions. *Healthc Inform Res* 2012;18(2):88-96.
 35. Wiederhold B. Ambient assisted living: a call to speed research and implementation. *J Cyber Ther Rehabil* 2012;5(1):7.
 36. Marschollek M, Gietzelt M, Schulze M, Kohlmann M, Song B, Wolf KH. Wearable sensors in healthcare and sensor-enhanced health information systems: all our tomorrows? *Healthc Inform Res* 2012;18(2):97-104.