Nursing Informatics Certification Worldwide: History, Pathway, Roles, and Motivation

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Summary

Introduction: Official recognition and certification for informatics professionals are essential aspects of workforce development. **Objective**: To describe the history, pathways, and nuances of certification in nursing informatics across the globe; compare and contrast those with board certification in clinical informatics for physicians.

Methods: (1) A review of the representative literature on informatics certification and related competencies for nurses and physicians, and relevant websites for nursing informatics associations and societies worldwide; (2) similarities and differences between certification processes for nurses and physicians, and (3) perspectives on roles for nursing informatics professionals in healthcare

Results: The literature search for 'nursing informatics certification' yielded few results in PubMed; Google Scholar yielded a large number of citations that extended to magazines and other non-peer reviewed sources. Worldwide, there are several nursing informatics associations, societies, and workgroups dedicated to nursing informatics associated with medical/health informatics societies. A formal certification program for nursing informatics appears to be available only in the United States. This certification was established in 1992, in concert with the formation and definition of nursing informatics as a specialty practice of nursing by the American Nurses Association. Although informatics is inherently interprofessional, certification pathways for nurses and physicians have developed separately, following long-standing professional structures, training, and pathways aligned with clinical licensure and direct patient care. There is substantial similarity with regard to the skills and competencies required for nurses and physicians to obtain informatics certification in their respective fields. Nurses may apply for and complete a certification examination if they have experience in the field, regardless of formal training. Increasing numbers of informatics nurses are pursuing certification.

Conclusions: The pathway to certification is clear and well-established for U.S. based informatics nurses. The motivation for obtaining and maintaining nursing informatics certification appears to be stronger for nurses who do not have an advanced informatics degree. The primary difference between nursing and physician certification pathways relates to the requirement of formal training and level of informatics practice. Nurse informatics certification requires no formal education or training and verifies knowledge and skill at a more basic level. Physician informatics certification validates informatics knowledge and skill at a more advanced level; currently this requires documentation of practice and experience in clinical informatics and in the future will require successful completion of an accredited two-year fellowship in clinical informatics. For the profession of nursing, a graduate degree in nursing or biomedical informatics validates specialty knowledge at a level more comparable to the physician certification. As the field of informatics and its professional organization structures mature, a common certification pathway may be appropriate. Nurses, physicians, and other healthcare professionals with informatics training and certification are needed to contribute their expertise in clinical operations, teaching, research, and executive leadership.

Introduction

Biomedical or health informatics has been firmly established as a professional discipline. Clinical informatics, a more specialized domain of biomedical informatics, supports health processes and outcomes in medical care and disease prevention by applying and managing data and information technology through electronic health records, decision support, documentation, order entry, analytics, and other functions [1]. Advances in the field of clinical informatics have included the increased adoption of electronic health records (EHR) in both ambulatory care and inpatient settings and the development of data warehouses for the collection, integration, and analysis of healthcare data [2]. This has been noted in developed and developing countries worldwide to a varying extent [3-6] [7-10]. In the United States (U.S.), a major boost to the field was the passage of the Health Information Technology for Economic and Clinical Health (HITECH) Act as part of the 2009 American Recovery and Reinvestment Act that resulted in widespread development of digital infrastructure and adoption of EHRs to satisfy meaningful use requirements [11-13].

Due to the complex nature of healthcare delivery and information systems, an important role emerged for healthcare providers with specialized informatics knowledge to protect the substantial investments in health information technologies. These individuals possess expertise in both healthcare and informatics, and so they are uniquely capable of synergizing healthcare delivery and infor-

mation technology. Nurses and physicians are two of the largest groups of healthcare professionals who have actively contributed to and advanced the theory and practice of clinical informatics. Nurses account for the overwhelming majority of the direct patient care workforce and increasingly assume operational, teaching, research, and executive roles such as Directors of Nursing Informatics, Chief Nursing Information or Informatics Officers [14], and the more recent Chief Clinical Informatics Officer position [15].

Attracting and retaining professionals in clinical informatics is critical for informatics workforce development. Opportunities for training and career advancement are particularly important. Voluntary 'certification' of professionals is a highly-visible quality indicator and a tool to improve recognition among peers. Fewer opportunities for certification in clinical informatics exists compared to certifications in allied fields, such as information technology and information systems. In the U.S., nurses developed a long-standing informatics certification program with fully developed competencies and expectations [16-18]. While physicians are eligible to apply for certification pursued by informatics professionals, few opportunities exist exclusively for physicians, including the board certification administered by the American Board of Preventive Medicine in the U.S. Currently, there are efforts underway in the U.S. to establish an interprofessional informatics certification [19].

We undertook a review of informatics certification pathways for nurses as a follow-up to a study on clinical informatics certification available across the globe for physicians [20]. The objectives are to describe the history, pathways, and motivations for certification in nursing informatics and compare and contrast those with board certification in clinical informatics for physicians recently addressed elsewhere [20-23].

Methods

As searches for 'nursing informatics' yielded a large number of results, the literature search was focused on 'nursing informatics certification' and 'nursing informatics competencies' to be able to determine past and

current trends. The search was performed via the University of Utah intranet on PubMed, Scopus, Web of Science, World Cat, CI-NAHL, and Google Scholar. A review of major nursing informatics societies discovered by Google searches was also performed for information on nursing informatics certification offered internationally. Further searches were conducted on journals dedicated to nursing informatics. Finally, informatics certification for nurses and physicians was compared with respect to the pathways and motivations for certification, including required training, published competencies, and perceived benefits.

Results
Search Results

The topics considered for this study (history, definitions, competencies, and pathways to certification) were selected before the literature search, based on the subject matter expertise of the authors. The literature search for key words 'nursing informatics certification' and 'nursing informatics competencies' yielded surprisingly few results in CINAHL, PubMed, Scopus, and Web of Science (Table 1). The same key word search in Google Scholar yielded a large number

Table 1 Search results using keywords nursing informatics certification and competencies (search as of January 2016)

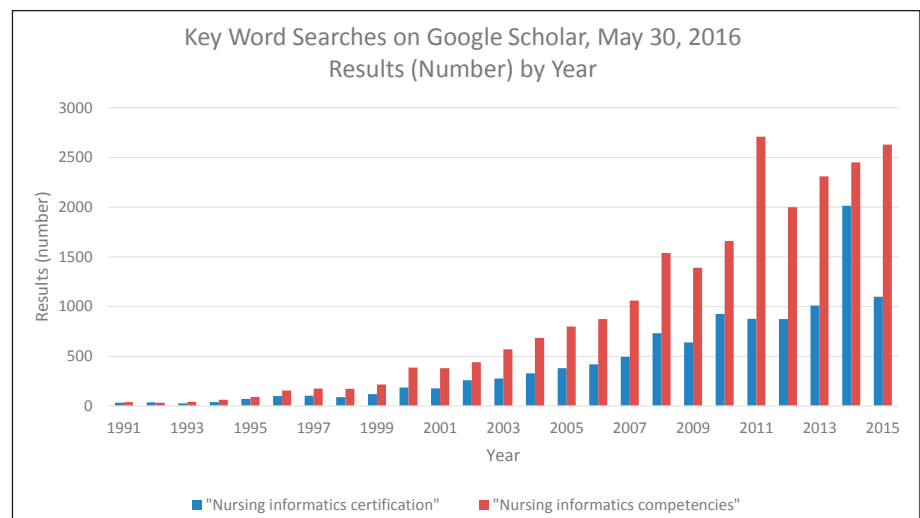|	Keyword: 'Nursing informatics certification' Number of search results	Keyword: 'Nursing informatics competencies' Number of search results	Types of references
CINAHL Journal Search	9	36	Academic journals, textbooks, conference proceedings, published papers, and news items from trade publications (magazines)
PubMed	43	211	
SCOPUS	99	240	
Web of Science	33	194	
WorldCat	235	1000	
Google Scholar	11,000	20, 300	

Fig. 1 Results of key word searches on 'nursing informatics certification and competencies' on Google Scholar

of citations that extended to magazines and other non-peer reviewed sources. As noted in Figure 1, a steady increase in citations is noted from the year 2000 for nursing informatics certification and competencies. The abstracts of citations retrieved from PubMed and CINAHL were reviewed for relevance. The majority of the published literature on nursing informatics certification and competencies is derived from the U.S.

There exist a limited number of nursing informatics societies and associations based mostly in North America, Europe, or Asia-Pacific regions. Several informatics societies and associations have dedicated working groups or special interest groups for nursing informatics. While peer-reviewed articles on nursing informatics are published in all nursing, medical, and informatics journals, there are a limited number of journals dedicated to nursing informatics or with the terms 'nursing and informatics' in the title (Table 2).

Table 2 Nursing informatics societies, associations, and journals dedicated to nursing informatics (search as of January 2016)

Nursing Informatics Societies and Associations	Journals Dedicated to Nursing Informatics or with 'Nursing and Informatics' in title
Australia Nursing Informatics Australia (NIA) http://www.hisa.org.au/nia/ **Canada** Canadian Nursing Informatics Association (CNIA) https://cnia.ca/ **England** National Nursing Informatics Strategic Taskforce https://www.networks.nhs.uk/nhs-networks/national-nursing-informatics-strategic-taskforce **Ireland** Health Informatics Society of Ireland - Nurses & Midwives Group http://www.hisinm.ie/ **Korea** Nursing Informatics Special Interest Group of Korean Society of Medical Informatics http://www.kosmi.org **New Zealand** Nursing Informatics New Zealand Incorporated (NINZ) http://www.hinz.org.nz/ **Singapore** Singapore Nurses Association — Nursing Informatics Chapter http://old.sna.org.sg/site/nursing-informatics/nursing-informatics.html **Taiwan** Taiwan Nursing Informatics Assocation http://www.ni.org.tw **U.S.A** Alliance for Nursing Informatics (ANI) www.allianceni.org Nursing Informatics work group of Healthcare Information and Management Systems (HIMSS) http://www.himss.org/library/nursing-informatics/ Nursing Informatics Working Group of the American Medical Informatics Association (AMIA) https://www.amia.org/programs/working-groups/nursing-informatics American Nursing Informatics Association (ANIA) https://www.ania.org/ The Nursing Informatics Special Interest Group of the International Medical Informatics Association (IMIA) http://imia-medinfo.org/ni/welcome	CIN: Computers Informatics, Nursing www.cinjournal.com Online Journal of Nursing Informatics (HIMSS Foundation) http://www.ojni.org/ Canadian Journal of Nursing Informatics http://cjni.net/

History and Definition of Nursing Informatics

Biomedical and clinical informatics is an inherently interdisciplinary and inter-professional field. Regardless of clinical background or licensure, informatics professionals share common historical roots to the mid-20th century emergence of computer technology in healthcare. The definitions of medical, clinical, nursing, and health informatics have evolved as we have gained a better understanding of the theory, practice, and prominence in modern healthcare. Clinical informatics has evolved into a full-fledged discipline of analyzing, designing, developing, implementing, and evaluating information and communication systems that enhance individual and population health outcomes, improve patient care, and strengthen the clinician-patient relationship [15]. Practitioners of clinical informatics have developed and learned from the use of health information technology (HIT) in everyday patient care to improve documentation, streamline and optimize ordering of medications and laboratory tests, reduce medical errors, promote the awareness, and practice of evidence-based medicine. The overall goals have been to improve the delivery, quality, and efficiency of healthcare which should in turn lead to improved quality of life for patients.

At the conceptual level, nursing informatics dates back to Florence Nightingale, who in the 1850's compiled and processed data to improve sanitation through nursing and medical protocols [24]. Nursing-specific engagement with information technology can be traced to the 1960s. More than 50 articles with titles referring to nursing and computers were found in the International Nursing Index in its first year, 1966 [25]. The first conference on nursing and computers was held in the 1970's in the U.S. [26] while informatics papers specific to nursing first appeared on the international level at MEDINFO in 1974, authored by nurses in the U.K. and U.S. [26]. Multiple, internationally organized efforts to promote nursing informatics followed, including the establishment of the International Medical Informatics Association (IMIA) Nursing Informatics working group in 1982 and informatics-related activity by the International

Council of Nurses (ICN) in early 1990s. In 1983, a newsletter called Computers in Nursing was founded in the U.S, the precursor to the scientific nursing informatics journal "CIN: Computers, Informatics, Nursing" (CIN) [27]. CIN's mission is "… *to advance the science of nursing informatics through peer-reviewed, evidence-based, original research and information from clinical and educational settings, to promote the specialty by disseminating information about relevant professional nursing informatics activities, and to provide a resource for all involved in the implementation and management of health information technology within the nursing and healthcare practice*". The journal is an endorsed publication of the Alliance for Nursing Informatics (ANI), whose member organizations include American Medical Informatics Associaton (AMIA), Healthcare Information and Management Systems Society (HIMSS), and the American Nurses Association (ANA).

In 1988, the first graduate program in nursing informatics was established in the U.S. at University of Maryland, followed soon after by a University of Utah nursing informatics program [28]. Nursing informatics was designated a specialty of nursing by the ANA in 1992, with written scope and standards for practice appearing in the years 1994-1995 [29]. Staggers, Gassert, and Curran identified an initial set of competencies for nursing informatics practice in 2001 [30]. Substantial additional work related to competencies has been conducted since that time, including work at the international level [31].

The original nursing informatics scope and standards of practice document was revised in 2015, to reflect changes in nursing informatics practice and technology. The Nursing Informatics Scope and Standards of Practice by the American Nurses Association defines nursing informatics as "the specialty that integrates nursing science with multiple information and analytical sciences to identify, define, manage, and communicate data, information, knowledge, and wisdom in nursing practice" [18]. The conceptualization of informatics nursing practice by ANA is grounded in the practice and process of nursing and focuses on the use of technology as it relates to nursing practice. The ANA describes two roles or

levels of practice within informatics nursing: The informatics nurse and the informatics nurse specialist. Informatics nurse specialists are distinguished from informatics nurses primarily by graduate specialty education in informatics or a related field. Informatics nurses and informatics nurse specialists hold diverse roles in healthcare and beyond, including executive, manager, analyst, consultant, educator, and scientist. It is the position of the ANA, an organization that represents the interests of nursing as a profession, that only educated, licensed registered nurses practice as informatics nurses or informatics nurse specialists.

Competencies for Nursing Informatics

As with any established discipline, much thought has gone into the core content and requirements for professional training and certification in nursing informatics. Keeping pace with advances in theory, practice, and technology in the field, these requirements have been updated at regular intervals [18]. There is a fairly well-developed body of literature describing competencies for nursing informatics, synthesized in the ANA scope and standards [18]. Moreover, there have been substantial organized efforts to address informatics competencies for nurses practicing in a variety of roles. The TIGER (Technology Informatics Guiding Education Reform) Initiative, sponsored by HIMSS, was established in 2006 to advance nursing education and workforce training in informatics [32]. Over the years, TIGER has evolved to encompass interprofessional workforce development. The TIGER international committee composed of representatives from 21 nations is currently developing a set of role-based, international core informatics competencies [33].

As noted by ANA [18] and others, including a recent review on this topic [15], domains of knowledge required for nursing informatics include fundamentals of informatics such as foundational knowledge of vocabularies, ontologies, concepts, and an understanding of the clinical and technical environment in which nurses function. A

working knowledge of design concepts, development, testing, implementation, and evaluation of available health information systems is essential. A key domain is clinical decision making and care process improvement. For nurses, this involves leading and participating in the development and implementation of clinical decision support (CDS) to fit the natural workflow of nurses and other clinicians. This assumes great significance with the ever-increasing documentation requirements of patient care activities. As nurses are asked to shoulder more responsibility in decision making with regard to following clinical protocols, their role in understanding the challenges of acceptance and adoption of CDS is critical for successful implementation. Similarly, theoretical and practical informatics skills, management concepts, and staff education (for peers and other clinicians) are part of the skillset. As is necessary for all clinicians and professional working in healthcare, knowledge of legal, ethical, and regulatory issues is also an essential component of the skillset for nursing informatics. These competencies have been articulated as the scope and standards of practice in nursing informatics [18] (Table 3).

Commonly, nurses acquire this knowledge in varying degrees of competency through either informal "on-the-job" training, experience, or continuing education programs such as an AMIA 10x10 course. Formal education opportunities include advanced training and degrees in nursing or biomedical informatics (certificates, masters with and without thesis options, and PhD), and prepare nurses to assume higher-level leadership roles consistent with the ANA-defined informatics nurse specialist role.

Pathway to Nursing Informatics Certification

In the U.S., board certification in informatics nursing is offered via the ANCC (American Nurses Credentialing Center), a credentialing body affiliated with the American Nurses Association, and accredited by both the American Board of Nursing Specialties and the National Commission for Certifying Agencies. The ANCC certification is the only

accredited informatics nursing certification available in the U.S., and it is open to international applicants. Applicants who meet both eligibility and practice requirements and successfully pass an examination are awarded the credential 'Registered Nurse – Board Certified' for a five year period [34, 35]. The eligibility requirements include a baccalaureate degree in nursing or a related field, licensure as a registered nurse (RN), two years' experience as an RN, and continuing education in informatics. A practice requirement can be fulfilled through nursing informatics practice, graduate level education in nursing informatics, or a combination of both. Graduate education in informatics is not required and the examination is tailored to the role of the informatics nurse versus the informatics nurse specialist. The content of the examination includes foundation of practice, system design life cycle, data management, and healthcare technology [36]. This sentence - please change to: Similar certifications for nursing informatics were not identified in other countries, including Canada, UK, Europe, or Australia.

Adoption of Nursing Informatics Certification

In the U.S., licensure for advanced practice nursing roles is tied to specialty board certification and is regulated by the states. However, the practice of informatics itself does not require a license as a registered nurse, a medical license, or any other type of healthcare provider license. Informatics not entailing direct patient care can be practiced by any individual as determined by a healthcare organization, and does not directly depend upon licensure or certification. Consequently, not all informatics nurses pursue ANCC certification in informatics nursing. Of the respondents to the HIMSS 2014 Nursing Informatics Workforce Survey, only 23% held ANCC certification in informatics nursing [37]. Moreover, graduate education in informatics nursing is not required for ANCC informatics nursing certification, and as a result, a graduate degree in nursing informatics is commonly viewed as an equivalent or superior mark of expertise in nursing informatics.

Nursing informatics workforce data indicate that the number of nurses with either graduate education in informatics or certification in informatics is growing. In the HIMSS 2014 Nursing Informatics Workforce Survey [37], more than half of respondents indicated they would be pursuing certification of some kind in the next year. Most planned to pursue ANCC certification in informatics nursing. Other respondents indicated they would pursue CPHIMS (Certified Professional in Healthcare Information & Management Systems), PMP (Project Management Professional), or CAHIMS (Certified Associate in Healthcare Information and Management Systems) certification. These certifications are agnostic of healthcare background and are not designed to validate informatics knowledge and skills specific to nursing. This preference reflects the frequently interdisciplinary or discipline-agnostic nature of clinical informatics practice and the fact that multiple certifications verify knowledge and skill relevant for informatics nursing practice. The HIMSS survey data represent the perspectives and viewpoints of nurses involved in informatics. The perspective of professionals such as managers involved in hiring nurses with informatics training or certification nurses is not described in the literature. Only ANCC certification requires licensure, and the primary influence on certification may well be employers, their stated or implied preferences, knowledge of nursing informatics certification, and explicit position requirements.

Comparison of Informatics Certification Processes for Nurses and Physicians

The field of 'Clinical Informatics' has evolved steadily and rapidly over the years to a full-fledged discipline of modern medicine. A recent position paper by the American Medical Informatics Association (AMIA) addresses the emerging role of Chief Clinical Informatics Officer (CCIO), a role that combines the Chief Medical/Nursing/Dental/Pharmacy Informatics Officer roles [15]. For physicians, Clinical Informatics was recognized in 2011 as a medical subspecialty

in the U.S. [20, 22]. This was the culmination of a 6-year effort by the American Medical Informatics Association (AMIA) [38]. Leading informatics professionals developed the core content and fellowship requirements [39, 40] that formed the foundation of clinical informatics as a distinct subspecialty [21, 41]. The subspecialty certification is co-sponsored by the American Board of Preventive Medicine and the American Board of Pathology. Until 2017, it is available to any physician, who possesses a license to practice and an unexpired board certification in any other specialty from the American Board of Medical Specialties, who can demonstrate more than 25% clinical informatics effort for three of the last five years prior to the date of the certification examination.

One of the motivations for the U.S. subspecialty certification was the recognition that informatics is now considered an essential component to the practice, education, and research aspects of all medical specialties and subspecialties [22, 42]. In the short-term, it is anticipated that the ability to show competency and expertise in this new field will act as a catalyst for the training and recruitment of experts to advance clinical informatics in hospitals and practices. In the long term, certification should allow for uniformity and standardization in training for physicians and prepare expert clinical informatics professionals. It is reasonable to assume that the desire and need to have qualified physician informatics specialists to fill positions such as chief medical/health informatics officers, directors of clinical informatics, and leads of EHR implementations will increase in the future.

The informatics skills or competencies required for certification for both nurses and physicians appear similar (Table 3). The practical difference may be in the perspective that each professional brings to the field and the depth of technical expertise required for specific tasks. As there is currently no requirement for physicians to obtain informatics certification in order to take on informatics-related roles, the primary influence to pursue certification may well be employers, their stated or implied preferences, and explicit position requirements, as appears to be the case with nursing. Thus, motivation for pursuing informatics certification appears to

Table 3 Comparison of informatics certification processes for nurses and physicians (U.S. perspective)

	Nursing Informatics Certification Informatics Skills/Competencies References: [18], [30], [43]	Clinical Informatics Board Certification for Physician (American Board of Preventive Medicine and American Board of Pathology) Informatics Skills/Content Outline References: [20], [22], [39], [40], [42]
Skills and competencies	Scope of nursing informatics practice: Foundational knowledge of metastructures, concepts, and tools, functional areas of nursing informatics; evolution of informatics competencies, ethics, the future of nursing informatics including trends in practice roles, technology, regulatory changes and quality standards, care delivery models and innovation. Standards of nursing informatics practice: assessment, diagnosis, problems, and issues, outcomes identification, planning, implementation, evaluation Standards of professional performance for nursing informatics: ethics, education, evidence-based practice and research, quality of practice, communication, leadership, collaboration, professional practice evaluation, resource utilization, environmental health	Informatics competencies as listed on the outline for board certification: leading and managing change, health information systems, fundamentals of informatics, clinical decision making and care process improvement, legal, ethical, and regulatory issues
Eligibility	Eligibility is limited to nurses with a baccalaureate degree in nursing; current R.N. license; two years' experience practicing as a Registered Nurse; experience practicing as an informatics nurse and/or graduate level practicum hours in informatics	Eligibility is limited to physicians with MD or DO degree; current, unrestricted medical license in the U.S.; current American board certification in primary clinical discipline or pathology
Practice requirement	ANCC certification requires up to 2000 hours of experience in informatics nursing. Practicum hours in a graduate nursing informatics program may also be used to satisfy the practicum requirement.	Accredited fellowship: 2 years Practice Pathway (25% time spent in informatics related activities for at least 36 months in the 5 years or acceptable 24 month informatics master or fellowship prior to taking the examination)
Validation domain	Certification validates knowledge pertaining to the informatics nurse role; informatics nurse specialists, those with graduate degrees in informatics, practice at higher levels than that implied by certification	Board certification validates practice based training and experience and/or formal training in clinical informatics (either advanced degrees or fellowships)
Duration of validity	Board certification valid for five years	Board certification valid for 10 years
Recertification	A minimum of 30 hours continuing education in informatics required for initial certification. Continuing education also required for re-certification.	Continuing education needs for maintenance of certification; requires examination once every 10 years

be similar in some respects for both nurses and physicians. To be eligible for certification, both nurses and physicians must possess a license in their respective professions and take an examination after satisfying the eligibility criteria for certification.

Discussion

The field of nursing informatics has evolved and matured over the years in parallel with the field of health informatics in general and has a prominent place in the field of clinical informatics. It is an established sub-discipline of nursing with growth and evolution noted in several countries in the form of dedicated associations, societies, and workgroups for nursing informatics. Furthermore, there are several peer-reviewed journals dedicated to nursing informatics

apart from research in the field being published in nursing and informatics journals.

The skillset required for the practice of nursing informatics is extensive and similar to the domains of skills, knowledge, and attitudes required for other informatics professionals including physicians. The pathways to acquiring these skills are also similar to those available to physicians and include formal training and study for advanced degrees in informatics and courses such as AMIA 10X10. Indeed, nurses and physicians find themselves classmates in many graduate informatics programs. Maintenance of informatics knowledge and skill requires continuing education for nurses as is the case for physicians. The primary difference between nursing and physician formal certification pathways relates to the role of formal training and level of informatics practice. Nurse informatics certification requires no formal education or training and verifies

knowledge and skill at a more basic level. Physician informatics certification requires completion of a two-year-long fellowship in informatics, and validates informatics knowledge and skill at a more advanced level. For the profession of nursing, a graduate degree in nursing or biomedical informatics validates specialty knowledge at a level more comparable to the physician certification.

Though there are several associations and societies dedicated to nursing informatics in several countries, formal certification in nursing informatics seems to be available only in the U.S. This certification has been available since 1992 and predates the clinical informatics board certification for physicians in the U.S. by 21 years. Nursing and physician certification processes share similarities with regard to skills and competencies required to demonstrate eligibility for and maintain certification in their fields. The motivation and need for obtaining formal

certification may be driven by prospects for positions in the field. However, this remains to be seen with respect to physicians, who at present do not need formal board certification in clinical informatics to take operational, teaching, research, or leadership positions such as chief health or medical informatics officers or directors of clinical informatics. This may change in the future as the norm for physicians in other sub-specialties of clinical medicine such as cardiology, nephrology, and infectious diseases is to have formal board certification to practice and take leadership positions in those fields.

There is no requirement for nurses or physicians to obtain certification for advancement. Graduate degrees in nursing or biomedical informatics imply informatics knowledge exceeding that evidenced by currently available nursing informatics certification. The motivation for completing certification requirements in nursing informatics is likely employer preferences or requirements and circumstances where certification leads to tangible benefits including new positions or titles. Current and future roles for professionals with nursing informatics training, degrees, and certification are in the areas of clinical operations, teaching, research, and executive leadership. With respect to clinical operations, there will be a continued need for those trained in nursing informatics to participate in the development and implementation of health information systems and clinical decision support. The nursing perspective is essential to successful design and implementation due to the large number of nurse users and the many clinical processes driven and affected by nursing workflow and patient care.

With sustained interest in nursing informatics, there is likely to be a continued need for qualified nursing informatics professionals to teach and train the next generation in all countries. There is already an established role for nursing informatics professionals in informatics research. Healthcare systems (small and large) have evolved into complex and dynamic organizations with nurses playing a key role in their day-to-day functioning, growth, and success. This has generated leadership opportunities for those nurses trained and certified in informatics; these include directors of nursing informatics,

chief nursing information/informatics officers, and chief clinical informatics officers. Examples of such executive leadership roles playing a key part in healthcare systems can be found the domains of transformational leadership, structural empowerment, exemplary professional practice, new knowledge discovery, innovations, and improvements, and improved empirical outcomes [44]. As the field of informatics and its professional organization structures mature, a common certification pathway for healthcare professionals may be appropriate [19]. Nurses, physicians, pharmacists, and other healthcare professionals with informatics training and certification are needed to contribute their expertise in clinical operations, teaching, research, and executive leadership. While the demands may be more apparent in countries with increased adoption of electronic health records and health information technology in general, these needs are global.

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