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Learning, Training and Teaching of Health Informatics and its Evidence for Informaticians and Clinical Practice

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Abstract. A globally agreed well structured framework representing the health informatics discipline's body of knowledge is yet to emerge. Considerable progress has been made towards describing this over the fifty or so years of the discipline's evolution. This contribution explains the need for such a structured body of knowledge from an educational and workforce capacity building perspective. Some examples of how education and training has been provided to date by a few key stakeholders/leaders are given and critical reviews of guideline and competency developments and their applications are presented. This is followed by an explanation of the need for linking health informatics research with education, learning and training strategies and desired future directions to overcome the identified health workforce knowledge and skills gaps are explored. Given the increasingly important role of health IT in health care, and the significant investment being made into Health IT systems and infrastructure, it is illogical not to seriously invest in health workforce capacity building.

Keywords. Medical Informatics, clinical informatics, competency-based education, Continuing education, professional education, health personnel, health informatics.

1. Introduction

As a professional discipline, health informatics is not well understood. Commonly used terms to describe this discipline are Health Informatics, or Medical Informatics or Biomedical Informatics or eHealth [1-4]. A number of authors have mapped publication trends or undertaken a knowledge domain analysis, or a scoping exercise as ways to define this domain [5-8].

As an emerging scientific discipline in most jurisdictions around the globe, it has been difficult to establish and sustain formal educational programs to suitably prepare the health workforce and improve the health workforce capacity. Amongst the lessons learned is that the health informatics discipline needs to remain cognizant of, and involved in, the aims and activities of health care itself. The benefits of using information and communication technologies to support health service delivery and management, as well as the ability to demonstrate such benefits to others, and avoid compromising patient/client safety, are increasingly becoming compulsory. Significant

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personal, organisational and national benefits are common expectations following substantial investments in training and education.

2. Learning, Educating and Training in Health Informatics

Learning is ideally student focused. The terms education and training are often used interchangeably although there is a difference in meaning. Education is about acquiring and reinforcing knowledge, whereas training is more focused on applying such knowledge to undertake tasks, and in informatics is usually linked to implementation or use of a specific system. Training is primarily about skill acquisition. Teaching covers both, it refers to the process of facilitating learning to take place. The scope of health informatics teaching covers three different audiences which are distinct, although each audience needs to be aware of the needs and priorities of one another. These groups are:

1. technical staff who develop, choose, implement or maintain systems and who need to know both its applied science and relevant engineering or technical discipline components as well as an overview of user interests;
2. end users (usually health professionals and their support staff) who use health informatics systems (often involuntarily) as part of undertaking their daily care delivery practice; and
3. managerial and policy staff who determine health IT policy and investment, as well as overseeing derived and secondary use of data.

Educational processes are guided by learner, organisational or industry interests, motivation and projected or established workforce knowledge, skill and behavioural needs requirements. This discipline's significant breadth and depth provide numerous educational options. Teaching strategies need to make use of well established educational theories and build on their students' foundational knowledge and skills to be effective. From a vocational perspective, learning outcomes are ideally linked to position or job roles that describe the required performance.

Higher education providers are focused on research and on contributing to the development and progression of a discipline's specific body of knowledge though unfortunately there is often a gulf between ICT research and teaching staff and health research and health professional education. Health informatics research outcomes are always about the computational and informational aspects of medicine and healthcare [9] within the context of any component that is relevant to the health industry. Evidence of the benefits to be achieved from health informatics education makes this attractive to students and other investors, increasing demand and making it financially viable for education and training providers. Unfortunately many are unaware of such benefits. The health workforce generally appears to have little or no appreciation of the need to improve their understanding of the health informatics discipline as evidenced by a common reluctance to address this need. Many stakeholders are unable to differentiate between IT skills and health informatics skills and knowledge, nor do they appreciate the importance of maintaining data safety and integrity or facilitating semantic interoperability, what each is and how they are best achieved. Many health service managers and policy makers do not appreciate the power and potential usefulness of health related information, the many technologies now available [10] and benefits of optimal use, nor indeed the related treatment or organisational risks of

adverse incidents. Nor do they understand the potential savings which could be achieved if health informatics expertise was leveraged in projects and planning. This is evident from the many system failures resulting from poor decisions made regarding acquisition, implementation and staff training/education support [11-12]. Bringing about a change in these perceptions requires the value, benefits and effectiveness of health informatics training and teaching to be demonstrated. A focus on the associated risks and additional costs incurred of not investing in health informatics training and teaching is another way of examining this issue to identify skill requirements.

2.1 Evaluating Benefits of Health Informatics Education, Training and Teaching

Educational evaluation studies tend to focus on graduate employment outcomes or learning effectiveness relative to various delivery methods. There is a dearth of evidence that demonstrates the benefits or return on investment of health informatics education from the perspective of improved health workforce capability and capacity relative to risk management, patient safety, quality of care delivered, patient outcomes, organisational performance effectiveness or efficiency. It is difficult to differentiate between system design, support or care deliverer usage as the cause of good or adverse system impacts as all of these factors interact with each other to process all types of data, information and knowledge. A systematic review of studies undertaken to evaluate the effectiveness of health related information skills training found that the majority of these were undertaken in academic settings rather than in hospital libraries or on practicing clinicians [13]. A literature review that aimed to identify attributes that lead to successful health information systems education and training within the healthcare context, revealed no explicit factors leading to successful health information systems education and training. The educational impact on information system usage was seldom explored or measured [14]. Studies have been undertaken to establish new skills required by the health workforce to enable them to function effectively in this digital age.

An opportunity for staff to acquire basic IT skills resulted in staff saving an average of 38 minutes a day because they were no longer struggling with IT; only 5% of staff who had successfully completed this course now required to call on IT support compared to 71% who did so regularly previously [10]. The acquisition of basic IT skills enabled them to learn to work with technology more quickly and more efficiently [15]. When preparing health information system users to safely manage health data, there needs to be a strong focus on risk management, legal and ethical compliance. A Healthcare unit (NHS Health) was developed by an international expert group convened by the ECDL Foundation and added to this ECDL portfolio in 2007 to meet this need. This study module is independently accredited by the ECDL Foundation, which has an accreditation partner in each country [16-17]. Subsequent studies have resulted in the development and adoption of a Health Informatics Career Framework (HICF) [18].

A similar career based focus was adopted by the Canadian Information and Communications Technology Council (ICTC), a not-for-profit national centre of expertise for the digital economy. A situational analysis of eHealth use was undertaken in a study of Health Informatics workforce requirements. This formed the basis for the development of their eHealth competency profile. Details are not publically available so these could not be compared with the UK career framework. Each profile is stated as consisting of:

- detailed descriptions regarding occupations, key activities and tasks, technical, business and interpersonal competencies where key activities represent desired learning outcomes or the skills and level of competency needed by someone to carry out a role in the workplace [19].
- a number of career clusters made up of work streams that share common competencies.

Career frameworks can be used as a basis for the development of workforce capacity building strategies. As health informatics is playing an ever increasing role supporting the delivery of health services, it is crucial that such use does not compromise the quality of care provided or become a catalyst for errors and adverse events. This issue was explored by the Institute of Medicine [20]. Their report explains the potential benefits and risks of health informatics. This committee found that the information needed for an objective analysis and assessment of the safety of health informatics and its use was not available. It was found that safety is the product of interactions within the larger sociotechnical system.[2] This includes technology, networks, people, processes, internal and external organisational structures, decisions regarding health informatics acquisition, application and incentives. The committee concluded that safer systems require efforts to be made by all stakeholders. This requires research, training and education of safe practices, including the need to identify measures that relate to the design, implementation, usability, and safe use of computational and informational processes by all users, including patients as well as the potential benefits of adopting new disruptive technologies. Workforce capacity building requires the identification of knowledge and skill requirements as these are used as a foundation from which all educational activities are developed.

2.2 The Health Informatics Domain (Body of Knowledge)

Professions that relate to health informatics, such as software engineers [21], computer scientists, information and communication technologists [22], health information managers [23], clinicians, biomedical scientists, and others representing a number of different professions have each defined their own body of knowledge that describes their specific knowledge and skills domain. Due to the extensive breadth and depth as well as the overlaps between and blurring of the boundaries of a number of these well established knowledge domains, it is difficult to gain consensus regarding a unique body of knowledge for the health informatics domain.

The International Medical Informatics Association (IMIA) has undertaken such a development task that began with a 'think tank' of experts and resulted in the identification of fourteen distinct topics representing a cognitive map of the health informatics discipline. This was followed up by the use of an extensive data extraction method that identified the most commonly used keywords published in the health informatics literature. This was followed by a consensus method to produce a final framework and knowledge base [24-25]. The resulting spreadsheet shows fourteen themes, each with numerous sub-themes, was endorsed by IMIA and complements its educational guidelines.

[2] See also: B. Kaplan, Evaluation of people and organizational Issues – Sociotechnical ethnographic evaluation, in: E. Ammenwerth, M. Rigby (eds.), Evidence-Based Health Informatics, Stud Health Technol Inform 222, IOS Press, Amsterdam, 2016.

Established disciplines are viewed as consisting of 'silos' of knowledge and skills, yet the health informatics body of knowledge needs to be fully integrated within all of these traditional roles as and where appropriate. A Health informatics body of knowledge may be viewed as an umbrella structure that accommodates, respects and calls on specialist contributions as and when required. The only way to overcome the currently perpetuating mismatch of objectives and values is to develop strong linkages via multidisciplinary teamwork.

An invited international group of experts in biomedical informatics and related disciplines agreed that 'biomedical informatics is an interdisciplinary field of study where researchers with different scientific backgrounds alone or in combination carry out research' when reflecting on this discipline, and that it is 'a very broad scientific field and still expanding, yet comprised of a constructive aspect (designing and building systems)' [26]. This focus on 'informatics' relative to all the disciplines concerned with and applied to the health industry in the broadest sense, is what essentially sets the Health informatics domain apart from all others. It is about the applied research and practice of informatics across the clinical, public health, health service management and health policy domains, covering numerous theories, methodologies and technological approaches within human, social, cultural and ethical contexts.

A formally documented body of knowledge is one that permits its use for purposes such as the development and accreditation of academically sound educational courses and programs, certification of specialists or for professional licensing. It sets the standard for professional practice, endorsement and accreditation criteria. It promotes the advancement of both the theory and practice for those who wish to specialise in any aspect contained within this domain. The body of knowledge needs to be underpinned by the scientific foundations for the domain. It is highly desirable to adopt a high level framework that encompasses this continuously changing body of knowledge with a focus on the processing of data, information and knowledge, and the technologies and people interactions used to achieve this within the health industry.

A globally recognized health informatics body of knowledge needs to be described using a structured format, yet it also needs to have sufficient flexibility to enable the inclusion of new knowledge in a timely fashion. Such flexibility is required for the development of innovative educational programs and delivery strategies to meet the educational needs of diverse student co-horts who need to focus on specific specialisations associated with certain roles or disciplines. Its objectives are to:

- Promote a consistent view of the health informatics body of knowledge worldwide, including the core (what needs to be known by the health workforce as well as health informaticians).
- Specify its scope and clarify its place with respect to other related disciplines and bodies of knowledge.
- Be publically accessible.
- Enable the identification of role specific competencies from which position descriptions can be developed and associated essential skills, knowledge and attributes identified to suit the many different types of health care organisation.
- Provide a foundation for health informatics course and curriculum design, development, accreditation and professional development program endorsements.

Many studies have been undertaken to not only describe this domain but primarily as the means to identify new knowledge and skills required by those working with these new technologies [27-29]. Such requirements are commonly expressed as 'competencies'.

2.3 Health Informatics Competency Studies and Frameworks

'Competence' describes the ability of an individual to successfully and/or efficiently perform a set of tasks within a role or function, in accordance with essential and desired requirements. Competency standards define these requirements and may be used as criteria against which learning is measured. Such standards need to specify not only the educational level it applies to, but also the learning topics that collectively constitute the standard. Each topic needs a list of performance criteria (what the student will be able to do in the workplace) or learning outcomes (what the student will have learned as a result), and prerequisite foundational knowledge and skills required to enable successful learning to take place. Ideally it also contains assessment requirements that stipulate the evidence required to demonstrate competence. Educational target groups may be defined in very general terms as:

1. end users - the entire workforce associated with the health industry in some capacity;
2. health informaticians - specialists in any area within the health or health informatics domain;
3. policy makers and policy implementers - decision makers regarding resource acquisition or distribution;
4. ICT professionals who design, develop, implement and maintain systems for the health industry.

Each of these groups and their individual members have very different educational needs depending on the role they need to perform. A consensus regarding commonly occurring role definitions (occupation standards) for any of the above is useful for educators and workforce planners [30]. The recognised need for health informatics capacity building has over many years resulted in numerous studies being undertaken [31-37] for a variety of purposes including specialist applications to suit various clinical specialties [38-40] These plus technology advances and experiences of the IMIA (International Medical Informatics Association) education working group members who had made use of its guidelines, resulted in a revision and update of the IMIA guidelines on education in biomedical and health informatics in 2010 [41]. Each study has its own focus and purpose.

An AMIA white paper focused on identifying the foundations of biomedical informatics as a scientific discipline and details core competencies for graduate study [42]. A needs assessment for training the biomedical informatics workforce in Latin America was undertaken by Quipu: The Andean Global Health Informatics Research and Training Center, across eleven countries [43]. The online survey questions were provided by local and international experts and included the opportunity to name additional courses. They were sent to 330 medical informatics and biomedical infomratics (MI-BI) related professionals. The results based on 142 surveys received, provided a consensus that the top four courses to be included are the introduction to biomedical informatics, data representation and databases, mobile health and courses

that address issues of security, confidentiality and privacy; a further 28 topics from the health informatics domain were identified as well as ten research priorities.

The Canadian HIP® competency framework, first developed in 2007 and updated in 2012 [44], details a core set of competencies as well as other more specialised competencies categorized according to Health Sciences (Canadian Health system and Clinical and Health services), Information Sciences (Information Technology and Information Management) and Management Sciences (Project Management, Organisational and Behavioural Management, Analysis and Evaluation) topics [45]. These core competencies have formed the basis for a more comprehensive HIP® program; version 3.0 includes a career matrix, role profiles and a credentialing process [46]. The Canadian Association of Schools of Nursing published its set of 'Entry to Practice' Nursing Informatics competencies for Registered Nurses in 2012 [47]. The Royal College of Physicians and Surgeons of Canada [48] has developed a set of recommended eHealth competencies for their members relative to seven roles they may occupy at any time throughout their career path. These have the potential to be applied to any other healthcare delivery related profession.

The US based Technology Informatics Guiding Education Reform (TIGER) initiative focuses on education reform and inter-professional community development to maximize the integration of technology and informatics into seamless practice, education and research resource development [49]. It has published Informatics Competencies for Every Practicing Nurse [50], developed a Virtual Learning Environment available to anyone at minimal cost, and it provides further educationally valuable resources to its international community. Their competencies model is based on basic computer competencies, information literacy and information management for which they recommend the use of existing standards such as the Information Literacy competency standards developed by the American Library Association [51], the Electronic Health Record Functional Model – Clinical Care Components, an ANSI standard developed by Health Level Seven (HL7) [52] and the European Computer Driving License [53]. The ECDL/ICDL Health Supplement module wasn't included in the list of recommended modules to be undertaken despite its successful 2006 US version trial [54].

Work in the UK undertaken by its Council for Health Informatics Professions (UKCHIP) has resulted in a registration scheme for three levels of health informatics professional using standards and an agreed code of conduct [55]. These standards were developed from a number of different sources and previous work. NHS informatics workforce development colleagues in England and Wales have worked together to develop a Career Framework for the Health Informatics profession (HICF) [18] last updated in 2011. Their document provides a diagrammatic representation of a number of other frameworks, including UKCHIP, and how these are linked to the HICF.

The Global Health Workforce Council [56] undertook a major project from a health information management perspective to provide a resource for academic programs across health information professions. This was a global attempt to amalgamate the work of these many and varied projects and to make use of these experiences and findings. Many overlaps between these three health information professional roles used for this study were encountered. Their draft publication is a well written educationally sound document. Its focus did not include clinical and other workforce users. Specialisations were not considered but will be considered for future work. This development work was the result of a transparent, consensus-based process.

Comments subsequently received noted that the work is based on traditional care models and practical experiences from well developed countries (USA, UK, Canada, Australia and elsewhere in Europe) [57]. Other comments received noted the need to identify a basic set of required competencies for all categories making up the health workforce and sets of competencies relative to existing health professional/workforce roles to ensure that all new health professional graduates are suitably work ready. All of these domain topics relate in various ways to overarching critical concepts such as the need to ensure patient safety, maintain confidentiality, data protection, and basic IT use relevant to specific job roles. Educators need to analyse these topics to identify and specify required knowledge, skills and behaviours for their educational programs.

A review of the many published competency statements and associated roles based on skill need studies revealed that required professional competencies in the health informatics domain [58] vary based on the many and varied perspectives and dimensions used to underpin these studies designed for a variety of different purposes, as demonstrated in Table 1. In addition most individual competency statements reviewed consisted of multiple concepts such as topic plus level of responsibility or role context in any one statement.

Table 1. Health Informatics Domain topics used as the primary focus skill and competency development studies selected to demonstrate differences.

Canadian HIP® competency framework – domain topics [44]	**Canadian Association of Schools of Nursing – domain topics** [47]	**T.I.G.E.R – domain topics** [49-50]	**Global Health Workforce Council – Domain topics** [56-57]
Health sciences: • Canadian Health System • Clinical and Health Services	Information and Knowledge Management		Health Informatics
Information sciences: • Information Technology Information Management	Information and Communication Technologies	Information literacy Information management	Health Information management
Managements sciences: • Project Management • Organisational and Behavioural Management • Analysis and Evaluation	Professional and Regulatory Accountability	Basic computer competencies	Health Information and Communication Technologies

2.4 Uses of Health Informatics Competency Frameworks

The AMIA's (American Medical Informatics Association) competency framework and definition of the Clinical Informatics sub-specialty has formed the basis for the American Board of Medical Specialty (ABMS) to create an approved certification process. A number of Clinical Informatics Fellowship Programs are now accredited by the Accreditation Council for Graduate Medical Education [59]. AMIA initiated their 10x10 program in recognition of an increasing need for a larger and better trained workforce in medical informatics. This took the form of an introductory medical informatics course (one subject). It provides a direct pathway to further informatics education. A number of Universities have partnered with AMIA to enable delivery of this course nationally via multiple methods to maximize the impact [60].

Not only do health professionals need to fill a knowledge gap, the same situation applies to ICT professionals working in the health industry. Successful application of health informatics requires knowledge about the business of providing health services.

Whilst there is some recognition (as in the examples described above) of health domain needs, there is little recognition by the IT community of their own knowledge gaps. This was recognized by the Computing Technology Industry Association (CompTIA) [61] who in 1992 introduced vendor-neutral IT certifications recognized globally. Their more recently developed CompTIA Healthcare IT Technician certification covers the knowledge and skills required to implement, deploy, and support healthcare IT systems in U.S clinical settings. An exam guide for this certification was published in 2013 [62].

Despite its development focus to suit the US market, much of the content is applicable to all ICT professionals and others working in or for the health industry. The Health Level 7 organisation also provides a certification service for the use of its standards. It could be argued that our focus for role definitions needs to be on data, their acquisition, secure, effective and timely transmission, and seamless exchange within and between health systems as well as its use [63]. All data processing requires the use of various health information technologies including compliance with data standards. Effective data processing generates knowledge that in turn also needs to be managed in a useful manner. New technologies enabling effective knowledge management continue to be developed and used.

A major challenge encountered during the development of health informatics competency frameworks is that new health informatics roles are emerging and are yet to be clearly defined. A competency framework needs to be able to identify various career path options from job role definitions. Emerging roles also encompass or are closely associated with existing professional roles, thus compounding this challenge. Career paths and educational pathways undertaken by current health informaticians are many and varied.

The 2010 edition of the IMIA recommendations on Education in Biomedical and Health Informatics [42] represents the most recent global framework available as these identify the need to differentiate between desired educational outcomes relative to a variety of job roles. They also meet recognised qualification requirements as these relate to any national educational framework and a range of health informatics positions. They are flexible and not prescriptive. Neither the IMIA framework, nor the IMIA Knowledge base is able to accommodate all of these concepts in a logical and more useful manner such as the Skills Framework for the Information Age (SFIA), a framework of professional skills needed by IT professionals [64]. CompTIA, a group described previously, has mapped its requirements to SFIA. This is one linkage framework identified by the UK's HCIF [18].

2.4.1 The Skills Framework for the Information Age (SFIA)

SFIA's success is demonstrated by its widely accepted global use [65]. The SFIA framework was developed collaboratively and first published by IT professionals and their employers, namely people with real practical experience of skills management in corporate and educational environments, in 2003. It provides a common language, is regularly updated, is now in its 6th edition, and is used in many contexts by educators, human resource managers (employers), professional organisations and individuals for career planning purposes in most countries around the world. It provides a common reference model incorporating unambiguous and clear definitions of IT based technical skills as well professional skills (totaling 96), along with definitions for up to seven

generic levels of attainment detailing autonomy, influence, complexity and business skills role requirements as detailed in table 2.

Table 2. Multiple cross referencing axial topics used in the SFIA Framework Structure [66].

High Level Topic groups	**Levels of responsibility**	**Generic skills defined for each level**
• Strategy and architecture – incl. governance, planning, consulting	1. Follow	**Autonomy**: Has authority and responsibility for all aspects of…
• Business change –incl. staff development, project management	2. Assist	**Influence:** Makes decisions critical to organizational success….
• Solution development & implementation – incl. socio-technical, data/system integration	3. Apply	
• Service Management – all operational functions	4. Enable	**Complexity:** Leads on the formulation….
• Procurement & Management support – incl. supply chain, compliance, risk & quality management	5. Ensure/advise	
• Client interface – incl. sales, client support, user interaction	6. Initiate/ influence	**Business skills:** Has a full range of strategic management and…..
	7. Set strategy, inspire, mobilise	

A mapping of health informatics competencies to SFIA revealed that this framework is not well suited for the health informatics body of knowledge and its applications, although the SFIA logical structure can be replicated. Health informatics requires formal naming and definitions of the concepts and fields represented within its domain together with clear definitions. The SFIA framework structure enables its use as a management tool as well as enabling the identification of suitable codes for the inclusion into a Standard Occupational Classification system. This is useful for the purpose of workforce planning and associated activities.

2.5 Health Informatics Curriculum Development

Educational program curricula ideally are designed according to job roles new graduates are likely to occupy. Learning outcome statements need to be specific, measurable and realistic in terms of a student's ability to successfully acquire the required knowledge, skills and attributes within the educational program's timeframe. Any educational program design needs to be undertaken in a manner that enables the evaluation of the effectiveness of such programs. Assessment guidelines, if available, are useful for this purpose. In summary, the health informatics curriculum development process requires the following factors to be considered:

- Industry/enterprise/workplace contexts and requirements –determine desired outcomes
- Desired training outcome – effects the choice of education/training delivery methods.
- Organisation or workplace goals – determine learning activities to be deployed for student/participant engagement to ensure outcomes reflect workplace readiness.
- Workplace application - determine practical placement and research opportunities

- Participant characteristics – determine the learners' starting points
- Learning styles of the participants – effect how individuals learn best and the choice of activity or educational delivery type and styles educators need to employ.
- Available learning resources or facilities – determine delivery options
- Equipment and consumable resources needed – determine delivery cost
- Topics, their depth and breadth to be covered – determine required resources, time and learning activities.
- Dimensions of competency required – determine educational level to be employed ranging from novice to expert or qualification type to be awarded.
- Qualification type – fits with relevant national education framework level

2.6 Health Informatics Educational Program Delivery

Whilst it is highly desirable to have health informatics content integrated in all preparatory health professional education [10][34][67], it is imperative that members of the health workforce are able to engage in lifelong learning and keep up with new developments [68] This is particularly relevant due to rapidly changing health informatics advances. Training undertaken to learn how to make use of a new application implemented in the workplace is in itself insufficient.

Clinical informatics is an increasingly influential part of the working environment of all clinical staff [69]. The European Universities that offered early Medical Informatics programs did include clinical informatics for medical students. In Germany this topic became compulsory in 1978 [9] and has remained so. Yet even today the inclusion of clinical informatics is still considered to be a rarity in many countries. Where offered this is usually as an elective or optional course. Attempts have been made to introduce and include the use of applications or medical informatics topics in general as core components of undergraduate medical or other health professional education [70]. Murphy et al. [67] noted that the most important factor holding up progress was the lack of staff with the knowledge and skills to provide academic leadership. This situation may in part be due to a lag in professional development curriculum accreditation requirements [71-73]. Ideally educators have the opportunity to make use of applications, such as electronic health records, as educational tools. Simulated systems could be made use of in skill laboratories to support the development of practical clinical skills.

Educational providers in many countries deliver an increasing number of health informatics programs [74] at various levels of complexity resulting in qualifications ranging from Bachelor degrees to PhDs or equivalent according to the prevailing national qualifications framework. Such formal University, or other Higher Education Providers' educational programs need to be combined with continuing professional educational programs that can be provided on an ad hoc basis for just in time learning, online, in the workplace or via seminars, workshops or via more formal short courses. The delivery methods will vary and may consist of any combination of coursework, online self directed study, practical work experience and research. It may be based on practical experiences, and/or consist of reading, assignment work, discussions, self assessment quizzes, project work and multidisciplinary problem solving activities.

2.7 Health Informatics Educational Program Accreditation

Course or program accreditation refers to a process for approval of a learning program leading to a specified qualification. Accreditation committees representing an accrediting organisation such as national government entities, Universities or Professional organisations make use of the quality assurance standards applicable to the relevant accrediting authority. Education providers need to identify the relevant accrediting authority and obtain their standards and accrediting guidelines to ensure curriculum compliance. The IMIA Education working group has developed such standards together with an accreditation protocol that may be used by health informatics educational providers in the absence of a relevant local accrediting authority [9][75-76]. Such providers are visited by IMIA representatives following the provision of a self assessment report that answers the following six main questions.

1. What are the goals of the program for which the institute asks for accreditation?
2. How are the goals implemented in a curriculum?
3. What is the size and quality of the staff?
4. Which facilities for teaching are available?
5. How does the institute guarantee the quality of the program?
6. Are the goals routinely achieved?

The IMIA accreditation procedure is based on the general higher education procedure in use by the Netherlands and Belgium and was tested on six health informatics programs, including a four year Biomedical Informatics Technologist program provided by a vocational technical educational provider [77]. The writing of the initial self assessment report was found to be beneficial for the management of the program itself as it provided a better insight into the quality of the program submitted for accreditation [76].

2.8 Government Initiatives Impacting on Health Informatics Training and Teaching

Governments have a leadership role to play by enacting legislation, appropriate regulations, including the need for standards compliance, and by providing suitable policy initiatives and funding. Some do this better and more comprehensively than others. From a health informatics education provider perspective it means that curricula need to include such national details. A survey paper found that usable IT systems do improve patient care. It explained the impact of recent regulations and patient safety initiatives (EU, US and Canada) based on findings from human factors usability studies and research that focused on Health Information Technology. [78]. Educators need to make use of such findings when updating their educational programs as they reveal workforce knowledge and skill gaps.

Health professionals, health software vendors and consumers need to be educationally prepared to enable them to effectively participate in the development of solutions to identified challenges encountered when Government, system or organisational initiatives are being implemented. Such initiatives establish new training needs, influence educational program development and may provide new health informatics training and teaching opportunities [79-80]. Most commonly new system implementations simply make provision for system usage skills development of staff.

2.9 Professional Initiatives

Most of the competency framework studies discussed previously were initiated and/or undertaken by professional organisations. Some received Government funding and/or considerable in kind support. Many relied on voluntary academic input. This review has found that Canada [45] and the United Kingdom [18] now have very sophisticated career matrices and defined roles as shown in table 3. These have been used by educational providers to develop and implement new educational programs as well as by employers to effectively deploy the health informatics workforce and by individuals for career planning purposes.

Various possible organisational models were explored to enable IMIA education workgroup members to 'teach globally and learn locally' to overcome the identified dearth of qualified health informatics educators during 1997-2004 [81]. Varied arrangements regarding credit transfers within qualifications, funding arrangements and national educational frameworks were obstacles it was unable to overcome although some student exchange programs are in place. Such desirable collaboration tends to be more achievable nationally or regionally. Web 3.0 now available is capable of transforming the Internet to a 'read, write and collaborative web' with the potential of promoting learning and enabling students and teachers to come closer to 'anytime anyplace' learning [82]. Many streamed health informatics lectures are now also widely available via YouTube and TED Talks. IMIA now has 47 academic institutional members making up its education working group.

Table 3. Professional Health Informatics Role high level comparisons.

Royal College of Physicians and Surgeons of Canada - Roles[48]	**UK Health Informatics Career Framework: Roles [18]** Total = 84 roles	**COACH HIP® Role Profiles Health Informatics Professional Career Matrix: Roles [45, 83]** Total = 65 roles
• Medical Expert	**Clinical Informatics Staff:** 13 different roles at 7 levels of seniority	**Clinical & Health Sciences** 6 roles at 5 levels of seniority
• Communicator/ • Collaborator	**Information Management Staff**: 14 different roles at 7 levels of seniority **Health Records and Patient Administration Staff**: 11 different roles at 6 levels of seniority	**Canadian Health System** 9 roles at 5 levels of seniority **Information Management** 13 roles at 5 levels of seniority
• Manager (now Leader)	**Project and Programme Management Staff:** 12 different roles at 7 levels of seniority	**Project Management** 6 roles at 5 levels of seniority
• Health advocate	**Knowledge Management Staff:** 7 different roles at 5 levels of seniority	**Organisational and Behavioural Management** 10 roles at 5 levels of seniority
• Scholar	**HI Educators and Trainers:** 10 roles at 6 levels of seniority	**Analysis & Evaluation** 8 roles at 5 levels of seniority
• Professional	**ICT staff:** 17 roles at 7 levels of seniority	**Information Technology** 13 roles at 5 levels of seniority

3 Discussion and Future Directions

Enabling the health workforce to make effective and safe use of available and emerging health informatics technologies and developments is a complex task. Formal recognition of the health informatics discipline, plus an ability of each healthcare organisation to develop their own required health informatics workforce competency

requirements, enables better workforce planning and education strategy developments to build health workforce capacity.

Organisational workforce frameworks enable the development of position descriptions together with an identification of relevant certification requirements. Collectively such frameworks could be used to develop an inventory of possible job roles to assist health informatics educators with the identification of knowledge, professional, technical and behavioural competency needs along with required experience and qualification levels. Individuals may also find this a useful resource for career planning. Adopting a standard approach will assist all of the above activities.

Competency statements derived from the many studies reviewed were found to be inconsistent concerning multiple learning topics reflecting differences regarding discipline specific professional profiles, potential roles and work environments. Adopting an ontological approach for the development of a competency framework enables a better mix and match of concepts for the generation of curricula development to suit well defined graduate outcomes. Such development is expected to provide agreed descriptions of a specific set of knowledge, skills and behaviours that collectively define the health informatics domain as a whole.

The SFIA framework structure provides a useful example for the provision of a flexible resource that can meet the needs of multiple users for various purposes. This differs from the UK and Canadian career matrices as it enables the compilation of unique individual job roles rather than matching to a previously defined job role. This is particularly useful as it enables the identification of any knowledge or skill combination to suit any healthcare organization's workload relative to each function. For example small regional healthcare facilities have a greater need to combine job roles/functions, such as nursing plus informatics, for individual positions. The IMIA Educational guidelines combined with the IMIA knowledge base provides a solid foundation for such a structured framework.

The health informatics domain is constantly changing as we learn more about new technologies and how and why the many current technologies in use fail to or are successful in meeting the needs of organisational or national health service delivery needs [84-85]. Such developments need to be able to be accommodated in the Health Informatics Competency Framework; they also need to be monitored by educators so that their curricula and teaching practices can reflect these changes.

4 Conclusion

The Health Informatics discipline continues to be regarded as an emerging one in numerous locations around the globe. Progress in health informatics education is continuing in a relatively small number of well developed 'western' nations. A number of initiatives are underway to address interdisciplinary conflicts occurring due to the nature of the health informatics knowledge domain, to overcome a dearth of well qualified health informatics educators and to develop the integration of health informatics into more traditional discipline based curricula. Recognition of this the health informatics discipline as a formally identifiable occupational category is slowly being addressed.

For as long as the different groupings of the workforce involved with health informatics remain untrained, systems will not be optimally designed or used, health informatics support will not achieve its optimum role in supporting health care delivery,

and there will be real risks to patients and to data safety and integrity. Given the increasingly important role of health IT in health care, and the significant investment being made into Health IT systems and infrastructure, this is anachronistic and illogical. To date the professional organisations have been active advocates to improve this situation with some success in a small number of countries.

This contribution has focused on various aspects concerning the learning and teaching of health informatics, the knowledge domain itself and the many studies that have been undertaken to identify required competencies. Competency statements need to complement career focused frameworks, and both are required as foundations for all types of educational program development and delivery. It is argued that making use of the globally endorsed SFIA structured framework as a model for developing a similar framework to suit the health informatics knowledge domain based on the IMIA educational guidelines and knowledge base would be beneficial. Once such a standard framework is available it is imperative that it is used not only by educators but also by organisations to establish their own workforce capacity needs profile, by health workforce recruiters who need to demand required skills and knowledge to meet workforce requirements and by individuals for career planning purposes.

Recommended further readings

1. E. Coiera, *Guide to Health Informatics*, 3rd Ed, CRC Press, Taylor Francis Group, Boca Raton 2015.
2. V.K.Saba, K.A McCormick (Eds), *Essentials of Nursing Informatics*, 6th Ed, McGraw-Hill Education.

Food for thought

1. Do you consider the SFIA example as a useful example to be made use of for the development of a health informatics competency framework?
2. Which unique high level health informatics concepts need to be made use of as axis for a multi-axial competency framework?
3. Are you able to identify and list health informatics concepts that need to be described for use in a health informatics competency framework under any of the high level concepts or topics?

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