# Competencies in Biomedical and Health Informatics

A Policy Paper
Presented to the Board of Directors of the
American Medical Informatics Association

Prepared by the Education Committee of the American Medical Informatics Association

## 1. Background

*1.1. Rationale*

On April 13, 2005, the AMIA Board of Directors gave general support to the goals and primary priorities of the 5-10 year horizon document also known as the AMIA Vision, Mission and Goals, articulated in the AMIA Strategic Plan (http://www.amia.org/inside/stratplan/). Goal III of the plan specifically calls on AMIA to expand the size of and strengthen the competency of the biomedical and health informatics workforce in the US and support the continued development of the biomedical and health informatics profession. Today, informaticians are not of one mind regarding the curricula needed for training informaticians throughout the discipline; nor do they agree on which criteria should be used in evaluating one's competency as an informatician. Nonetheless, as we are challenged to increase the biomedical and health informatics workforce, we also must ensure that the workforce we produce is well prepared—and has the needed competencies to practice efficiently and effectively.

The formalization of competencies is a symbol of maturation and formalization of the profession. AMIA is a leader in biomedical and health informatics and, as such, should take the lead in producing standards for the education and assessment of the competency of those practicing in the discipline. This formal articulation of policy related to biomedical and health informatics competency will further enable AMIA to promote the discipline as a career choice. A competency standard will also provide guidance to students and program developers when choosing or creating informatics training programs, and to recruiters and employers when seeking talent. In addition, the competencies will communicate to others what informaticians "do," serve as a guide for career development. However, identifying and codifying informatics competencies in informatics must not discourage diversity in the field nor establish guidelines for exclusion from the field. On the contrary, however we proceed must enable the definition of new roles, new aspects of roles, and the requisite competencies that facilitate the evolution of an already diverse discipline.

The adoption of a "living" competency standard ultimately serves all of those who have formal informatics training, as well as those who have proceeded along informal self-directed lines, to demonstrate that they possess the skills and knowledge necessary to function as an informatician. Ultimately, a competency standard should provide a metric that allows the assessment of an individual's qualifications as an informatician and the formal recognition by the professional informatics community that the individual satisfies the requirements for membership in that community.

The ultimate goal of this endeavor is a clear definition of the discipline of biomedical and health informatics, so that all within the field and beyond will know what the discipline is and what informaticians are competent to do. Part and parcel of this definition is the articulation of the knowledge, experience, skills, attitudes, and values possessed and used by informaticians and transmitted in various biomedical and health informatics educational and training programs.

*1.2 Defining the Discipline*

For the purpose of this report and further discussion on the issues surrounding competencies, biomedical and health informatics is defined as the *field that studies information and knowledge in biological research, in the clinical sciences, and in health care delivery, encompassing the structure, discovery, acquisition, integration, management, and optimal use of biomedical knowledge.*

Biomedical and health informatics is no different from other disciplines that face challenges and require competent solutions founded in a set of formally articulated competencies. However, biomedical and health informatics is unique because it is a multidisciplinary discipline that has both research and applied components. Informaticians may serve in clinical, administrative, education, research and development, or other practice roles. Often informaticians carry out several roles simultaneously. In its broadest sense, biomedical and health informatics includes the study and practice of a number of disciplines, such as medicine, nursing, computer science, psychology, sociology, economics, and management science. Biomedical and health informatics professionals must adopt, apply, evaluate, modify, and expand research evidence and methods from a variety of disciplines including: Information Science, Computer Science, Library Science, Cognitive Science, Business Management and Organization, Statistics and Biometrics, Mathematics, Artificial Intelligence, Operations Research, Economics, Epidemiology, and of course, Basic and Clinical Health Sciences. However, ultimately biomedical and health informatics is an integrative discipline that is substantially more than the "sum of its parts."

The complex nature of biomedical and health informatics does not mitigate the need for, or the possibility of, identifying a set of competencies common to all of the roles and component disciplines found in the field. In fact, it is essential to consider all possible competencies to identify which of them cross all roles and component disciplines. Furthermore, it is possible that there will be levels of competency, in that junior or entry positions may not require competencies at the same depth or breadth as "higher levels;" it is also probable that these levels may change in content or intensity over time. As a result, the identification of biomedical and health informatics competencies must be a dynamic process that accounts for a constantly changing academic and professional environment, while accounting for the many varied roles informaticians are expected to fill. Finally, it is also possible that biomedical and health informatics competencies might be "fuzzy" in nature, so that conceptual overlap that may occur between different competencies can be considered.

## 2 Competencies in biomedical and health informatics

Competencies, in a general sense, can be viewed as the minimal knowledge, skill, values, experience, and judgment that a person needs to possess in order to function within a specific role in a particular craft or profession. In a given role, there exist a set of commonly encountered challenges that can be addressed through professional competencies. In some cases, these challenges may be unlike those previously encountered; however, a competent practitioner should be able to draw upon a set of fundamental (or "core") competencies to construct

solutions that meet these novel challenges. We view these core competencies as the necessary but possibly not sufficient competencies to function effectively in a field. These competencies form the basis for successful practice in one's profession.

*2.1. Certification*

Certification based on agreed-upon core competencies will benefit individuals, their prospective employers, and the biomedical and health informatics community at large. Certification in biomedical and health informatics can improve individuals' attractiveness to prospective employers, clarify their informatics-related roles and expectations, and strengthen their position within an organization, compared to informal and usually vague representations as the "computer expert" on a clinic committee, etc. For employers, certification can provide the basis for the more objective and relevant assessment of prospective employees, for assigning responsibilities, and for resourcing organizational goals. For the biomedical and health informatics community as a whole, certification of individuals will strengthen our recognition and status as an academic discipline and an applied profession.

Two possible certification pathways exist: *certification independent of another certifying body* and *specialty or sub-specialty certification within a clinical or other discipline.*

*2.1.1 Independent certification of individuals, independently of other certifying bodies*

Defining competencies in biomedical and health informatics will support the certification of individuals as they enter and practice in the discipline, even outside of the context of a clinical specialty. Those serving in healthcare environments as systems analysts and architects, software developers, process engineers, or systems integrators would be likely targets of this type of certification approach, primarily because these individuals do not ordinarily possess a professional certificate in their field. For example, there is no professional licensing or certification examination in information systems architecture.

One approach to this constituency is to ensure uniform certification across professions and specialties by an idependent certifying body external to them, such as AMIA. An example from the technical domain is certification in software engineering. Two relevant examples from the clinical domain are certification in clinical genetics and training in Advanced Cardiac Life Support (ACLS). ACLS education and testing are the same for all trainee,s regardless of professional background (physician, nurse, paramedic), and are determined by an entity external to any single profession, the American Heart Association. This approach is especially suited to situations where a well defined and limited set of competencies is required, and provides greater predictability for all concerned. If one is ACLS certified, others know precisely what that means.

*2.1.2 Specialty certification within another discipline*

Several models currently exist for certification within various professions and subdisciplines. One model is parallel certification within existing professions, such as nursing, pharmacy, or medicine. For example, in geriatrics, entirely separate specialization and certification processes exist for nurses, who become Geriatric Nurse Practitioners; for pharmacists, who can train and obtain a certificate in Geriatric Pharmacy; and for physicians, who may obtain Added Qualification in Geriatrics. In each case, the process and requirements for certification are determined within existing profession-specific organizations, such as the American Nurses Association, for nursing, and the American Board of Medical Specialties, for physicians. There is growing interest in this approach, as evidenced by the current AMIA project, sponsored by

the Robert Wood Johnson Foundation, to develop core content and training requirements for subspecialty certification for clinical informaticians.

One example of this approach to biomedical and health informatics certification already exists in nursing. Efforts to define informatics competencies for nurses began in 1988, when the National League for Nursing published categories of informatics competencies developed by an International Medical Informatics Association (IMIA) workgroup (Grobe, 1989; Peterson & Gerdin Jelger, 1988). At about the same time, the American Association of Colleges of Nursing (AACN) and the National Advisory Council on Nursing Education and Practice (NACNEP) published guidelines on nursing education related to information technologies. In 1999, IMIA approved core informatics concepts for biomedical and health informatics users and specialists (IMIA, 1999). Also in 1999, AMIA focused its 1999 Spring Congress entirely on informatics education for health professionals (Staggers, Gassert, & Skiba, 2000).

Building on those efforts, researchers have identified informatics competencies for nurses at four levels of practice (beginning nurse, experienced nurse, informatics nurse specialist, and informatics innovator) (Staggers, Gassert & Curran, 2001, 2002). The researchers initially derived a list of potential nursing informatics (NI) competencies from the extant literature, as well as from job descriptions of practicing informaticians. The researchers then classified the competencies into three broad categories: computer skills, informatics knowledge and informatics skills, which were subsequently divided into 22, 10, and 25 subcategories, respectively. In 1998, the AMIA Nursing Informatics Working Group was invited to help validate the items as important to NI practice; and in 1998, an expert panel of doctorally prepared nursing informatics representatives from both academia and service were convened to further refine the competencies. It was soon discovered that such refinement could not occur without first defining the context of practice. Therefore, the four levels of practice listed earlier (beginning nurse, experienced nurse, informatics nurse specialist, and informatics innovator) were used to "level" the competencies. The researchers then used a Delphi study to achieve consensus on the list of competencies. A final list of 281 competencies emerged (Staggers & Gassert, 2000; Staggers, Gassert & Curran, 2002).

Certification efforts paralleled the development of competencies. In 1994, the American Nurses' Association published the Scope of Practice for Nursing Informatics; in 1995; they followed that with the Standards of Practice for Nursing Informatics. Both were reviewed and integrated in 2001. In 1995, the American Nurses Credentialing Center (ANCC) began to offer informatics certification. Since 1995, over 500 nurses have successfully passed the certification exam.

## 3. The biomedical and health informatics competencies retreat

At its meeting during the 2001 Annual Fall Symposium, the Education Committee discussed the need to identify "core biomedical and health informatics competencies" that would achieve three purposes: 1) help define the educational goals of biomedical and health informatics training programs, 2) provide a set of expectations that could be applied to individuals working in the field, and 3) assist management in defining roles for informaticians. At this meeting, the Education Committee voted to hold a retreat or similar activity to discuss the identification of these competencies. Shortly thereafter, the Chair learned of an effort in ACMI to analyze the

NLM-funded Biomedical Information Science and Technology Initiative (BISTI), and particularly the BSTI programs. The two initiatives were determined to be complementary, rather than competitive, and it was agreed that Dr. Charles Friedman and one other member of his group would participate in the Education Committee's initiative to ensure that the two groups did not work at cross-purposes.

In June 2002, the Education Committee was charged by the AMIA Board of Directors to conduct a retreat at the 2002 Fall Symposium. The retreat was held on November 13-14, 2002. During the retreat, considerable attention was paid to developing working definitions of biomedical and health informatics and competencies that would represent the diversity within the AMIA membership and the field as a whole. It was decided that the Committee would to develop a preliminary competencies ontology and use this ontology as a framework for gathering competency definitions from the broader AMIA membership.

*3.1. Competencies taxonomy*

A preliminary, high-level competency taxonomy was developed by consensus of the AMIA Education Committee. The taxonomy was intended to assist AMIA members in thinking about competencies by providing high-level conceptual structure to to the complex task of identifying competencies. The taxonomy is illustrated below.

A. Data Information and Knowledge: Representation and Structure
B. Data Information and Knowledge: Analysis and Manipulation
C. Healthcare Systems
    C.1: Healthcare Applications Systems
    C.2. Intelligent Health Systems
D. Information Technology
    D.1. System Architectures
    D.2. Health Communication Systems and the Health Technologic Infrastructure
    D.3. System Customization/Development Topics
E. Health Information Systems: Education and Training Topics
F. Health Research Systems
G. Users and Use of Health Information Systems
    G.1. The Health User Interface and Interactive Systems
    G.2. Human/Social Aspects of Health Information and Communications Systems
H. Management and Operations of Health Information Systems
    H.1. Technology Management Topics
    H.2. Procurement and Implementation Topics
    H.3. Vendor/Service Provider Topics
    H.4. Project Management Topics
    H.5. Systems Maintenance and Support Topics
    H.6. Security Management Topics
    H.7. General Topics for IT Professionals
    H.8. General Business and Management Topics
    H.9. Team and Human Resources Management Topics
I. Design and Evaluation of Health Information Systems
    I.1. Assessment of the Effects, Value, and Cost of IT
    I.2. Re-engineering and Management of Change Topics
    I.3. User and Process Observation and Assessment Topics
J. Professional Skills: Personal Topics for IT Professionals

*3.2. Online Delphi*

An online Delphi round was performed using AMIA's web resources. The advantage of using an open Delphi approach is that participants can see what competencies and rankings others have identified. Participants were free to enter the same or different responses from what they saw on the system, but once they completed their session they were not allowed to re-enter the Delphi system to prevent duplicate responses by the same participant.

AMIA members were invited by email to participate in the Delphi process. After authentication, respondents were asked to complete a questionnaire that was structured as a two-dimensional matrix, wherein the rows represented the individual components of the high-level competencies taxonomy described above. Two columns represented the professional role for which a specific competency could be appropriate: Applied (such as a clinical) Informatician or Research (such as an academic) Informatician. Respondents were asked to enter specific competencies (in free text) into the matrix cells according to their judgment of where the competencies best fit within the taxonomy and role classification. Each entry was classified by the respondent ordinally according to depth of knowledge using this scale: *Aware*, *Casual*, *Knowledgeable User*, *Expert User*, *Designer*, or *Researcher*. All responses were anonymized, thus obviating the possibility of identifying individual participants. However, each response was date- and time-stamped to evaluate the each respondent's entry.

*3.3 Results*

The initial Delphi round took place over the period July 7 through September 26, 2003. Since the system did not assign an anonymous unique identifier to each participant, it is not possible to determine exactly how many individuals participated in the Delphi process. However, an informal analysis of the log-in data indicates that at least 52 participants, using a minimum of five minutes between entries as indication that the entries were made by a different user. It is possible that this criterion imposes too severe or lax a constraint, so no further analysis of user data will be reported here, and this report thus focuses on the competencies that were entered by the participants. .

A total of 400 individual competencies were entered. Table 1 (Appendix 1) shows the frequency of all competencies entered for each of the major dimensions of the taxonomy, stratified by role and ranking as determined by the participants as they entered the competencies. Competencies clustered most frequently in dimensions A, B, C, and D for both informaticians roles. Not surprisingly, Dimension H is most frequently represented in the Applied Informatician role, and across the ranking spectrum; this dimension is also represented in the Informatics Researcher role, primarily in the user-oriented rankings but also in the researcher ranking. It is interesting to note the number of competencies reported for the Researcher role in the dimensions that would not necessarily be expected to attract researchers in the traditional sense, such as dimensions H and I (Appendix 1).

## 4. Summary and recommendations

As certification programs appear and evolve, several issues need to be resolved, including the various forms this may take, as discussed above, the various levels of certification that might appear (basic, intermediate, and advanced,), and how such certification might or might not be linked to degree granting programs at the baccalaureate, master's, and doctoral levels. There also will be an increasing need for clarity about what certification, in whichever form it may take,

actually means in terms of the knowledge and skills required. AMIA can and should continue to play a leading role in the process of resolving these issues.

AMIA could use identified competencies to set the standards for individual professional certification or for providing such certification. It is clear that any set of competencies can and may be used by AMIA or other organizations to create one or more certification examinations. This should be regulated to the extent that AMIA would take the lead in defining the competencies for not only the field in general but within each subspecialty of biomedical and health informatics and each level of training (Bachelors, Masters, Doctoral levels). In addition AMIA should specify how the competencies are intended to be applied.

Several specific recommendations for AMIA to pursue as the organization and biomedical and health informatics move forward are offered here.

1. **Competency identification and modeling.** Gather and analyze additional data on competencies required for various biomedical and health informatics roles. Expand the data collection process to as many AMIA members as possible, including deans, chairs, and faculty in a broad range of biomedical and healthcare academic programs and leaders in industry. In addition, competency efforts from others in the field, such as public health and nursing, need to be examined, analyzed, and harmonized. We recommend that an existing model-based approach, developed by the Waterloo Institute for Health Informatics Research (http://learningspace.uwaterloo.ca/hi/index.php) should be used as a framework for this effort. The data collected and harmonized during this process should be used to develop and refine any certification effort undertaken in the future. In addition, these data should be considered in addressing the issue of training program accreditation, although no specific recommendations to undertake accreditation are offered here.

2. **Interaction with the RWJ/AMIA project.** The work of the ongoing RWJ/AMIA project to establish biomedical and health informatics certification in clinical specialties is essential to the Education Committee's work on broader informatics competencies, and vice-versa. A formal mechanism for sharing information between these efforts should be established.

3. **Resources.** Resources are needed to continue the work of identifying biomedical and health informatics competencies and establishing the landscape of the field. In addition, resources are needed to maintain and update competencies as they evolve over time. A budget for this effort is proposed in Appendix 2.

4. **Specialty and sub-specialty certification.** Continue to pursue specialty or sub-specialty certification for informaticians who are members of professional organizations offering certification. This work has begun under the RWJ Foundation project. Other, non-health professional organizations that may have an interest in biomedical and health informatics should be approached as possible targets for certification. Any efforts toward promoting certification should be as inclusive as possible, including professionals who practice biomedical and health informatics.

5. **Determine the perceived value and utility of individual certification.** Formally and rigorously survey of AMIA membership, academic institutions, and representatives of the healthcare industry to ascertain if individual certification is useful and/or needed. Assuming that such certification is useful,
    a. Investigate approaches to certification for informaticians who do not belong to organizations offering certification. One approach could be that used in the field of human genetics.
    b. Develop pathways to certification through AMIA

    c. Develop guidelines and tools for the assessment and selection of health informaticians by recruiters and employers.

# APPENDIX 1

## Results of the Delphi rounds to ascertain user-identified competencies

| Competency | Applied Informatician | | | | | | Informatician Researcher | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aware | Casual user | Knowledgeable User | Expert User | Designer | Researcher | Aware | Casual user | Knowledgeable User | Expert User | Designer | Researcher |
| **A. Data Information and Knowledge: Representation and Structure** | 0 | 4 | 21 | 26 | 11 | 0 | 0 | 2 | 3 | 14 | 11 | 33 |
| **B. Data Information and Knowledge: Analysis and Manipulation** | 8 | 5 | 17 | 15 | 4 | 0 | 2 | 0 | 6 | 11 | 8 | 19 |
| **C. Healthcare Systems** | 3 | 10 | 17 | 21 | 1 | 0 | 1 | 0 | 5 | 2 | 9 | 31 |
| **D. Information Technology** | 4 | 5 | 22 | 16 | 11 | 0 | 4 | 3 | 2 | 3 | 36 | 8 |
| **E. Health Information Systems: Education and Training Topics** | 2 | 1 | 6 | 4 | 3 | 0 | 0 | 0 | 4 | 6 | 4 | 2 |
| **F. Health Research Systems** | 4 | 3 | 8 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 4 | 12 |
| **G. Users and Use of Health Information Systems** | 0 | 1 | 6 | 8 | 10 | 1 | 1 | 0 | 3 | 2 | 3 | 17 |
| **H. Management and Operations of Health Information Systems** | 5 | 5 | 14 | 37 | 15 | 3 | 2 | 11 | 10 | 8 | 4 | 10 |
| **I. Design and Evaluation of Health Information Systems** | 2 | 0 | 5 | 7 | 5 | 0 | 0 | 0 | 2 | 0 | 0 | 11 |
| **J. Professional Skills** | 0 | 3 | 6 | 2 | 3 | 7 | 0 | 1 | 3 | 4 | 4 | 8 |

Table 1. Frequency of competencies entered by Delphi participants, aggregated within each major dimension of the taxonomy.

# APPENDIX 2

*The proposed budget in appendix 2 has been removed for the purpose of mounting this document on the AMIA Website.*