October 30, 2023

U.S. Department of Labor
200 Constitution Avenue NW
Washington, DC 20210

Re: Need for "Clinical Informatics" Occupational Code

Dear Ms. Frugoli:

We encourage the Occupational Information Network (O*NET) to further study the "Clinical Informatics" field with the information in the application attached. We recognize and appreciate that O*NET currently has the Health Informatics Specialist code (15-1211.01), but this code does not adequately capture the breadth of the field.

Informatics is the science of how to use, data, information, and knowledge to improve human health and the delivery of health care services.[1] In a medical context, informatics is an "important tool to control and address public health concerns using an interprofessional team of physicians, nurse, pharmacists, and public health workers,"[2] and potentially other medical professionals. For example, informatics is necessary in tracking immunizations, implementing plans for community health care access, and ensuring patient record privacy and safety.

The Health Informatics Specialist code is a great start but given that it was adapted from the Informatics Nurse Specialists code, it does not capture expertise of all the professionals working in this field.

Currently, all informatics positions are under the major Standard Occupational Classification (SOC) Code group 29-0000, Healthcare Practitioners and Technical Occupations. There was a request by AMIA in 2014 to add 3 detailed codes to add additional SOC codes specifically to include Health Informatics, Health Information Managers, and Health IT occupations for the 2018 SOC Revision Process.[3] As a result, the 2018 SOC code contains a new detailed occupation 29-9021 Health Information Technologists and Medical Registrars which is meant to capture health informatics specialists and similar workers. The request for specific SOC codes was denied based on Principle 9, due to lack of data. Classification Principle 9 deals with "collectability" – that is, whether data can be collected on the occupation.

Principle 9:

> *"9. The U.S. Bureau of Labor Statistics and the U.S. Census Bureau are charged with collecting and reporting data on total U.S. employment across the full spectrum of SOC major groups. Thus, for a detailed occupation to be included in the SOC, either the Bureau of Labor Statistics or the Census Bureau must be able to collect and report data on that occupation."*[4]

Given this feedback, we now submit this application to O*NET, the nation's primary source of occupational information, in the hopes that the O*NET-SOC taxonomy on 923 occupations can help us

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[1] https://amia.org/about-amia/why-informatics/informatics-research-and-practice
[2] https://www.ncbi.nlm.nih.gov/books/NBK470564/#:~:text=Informatics%20involves%20the%20practice%20of,interaction%20between%20humans%20and%20information.
[3] AMIA-Responds-to-Proposed-Updates-to-Standard-Occupational-Classification-Codes.pdf
[4] https://www.bls.gov/soc/revising_the_standard_occupational_classification_2018.pdf

better understand the existing data on the field of clinical informatics. We plan to follow up this application to O*NET with a comment letter to the SOC Policy Committee (SOCPC) regarding an SOC code for “Clinical Informatics” when the next SOC solicitation opens.

It is our stance that there is a massive gap in the SOC due to the lack of acknowledgment of Informatics. After a three-year public health emergency where the healthcare workforce functioned not only as essential workers, but as the nation’s frontline, this is especially troubling. We urge you to further develop the occupational codes relevant to “Clinical Informatics” and gather data on this field that can then be shared during the next SOC solicitation to ensure this medical specialty is acknowledged and can be part of the government’s national occupational data capture. Please see our attached materials for more information on this vital occupation.

American Medical Informatics Association (AMIA)
Alliance for Nursing Informatics (ANI)
American Academy of Family Physicians
American Nursing Informatics Association (ANIA)
American Nursing Informatics Association – Midwest Chapter
AORN Syntegrity
Association of Medical Directors of Information Systems (AMDIS)
Association of PeriOperative Registered Nurses
Carrie Baker DO LLC
Children’s Healthcare of Atlanta
The Christ Hospital Health Network
Clinical Architecture
Confluence Health
Creighton University
Dayton Children’s Hospital, Dayton OH
Fairview
Fitzgibbon Hospital
Geisinger Health System
Greater Lawrence Family Health Center
Health Mart Pharmacy Bayonne
Hennepin Healthcare
Healthcare Information and Management Systems Society (HIMSS)
Kettering Health
Mass General Brigham
Medical Networks, LLC
Middleton Informatics
Moffitt Cancer Center
Nationwide Children’s Hospital
NextGen Healthcare
Northeast Georgia Health System
Rochester Regional Health, Rochester, NY
Samaritan Health Services
Shirley Ryan AbilityLab
Stony Brook Medicine
UCLA Health

UC San Diego Health
University of Arkansas for Medical Sciences
University of California Irvine
University of Rochester Medical Center
UPMC Clinical Informatics Fellowship Program
US Air Force
VA's Veterans Health Administration
Yuma Regional Medical Center

U.S. Department of Labor

Employment and Training Administration

Occupational Code Assignment (OCA) Form – Part A

Request Number:	Analyst:	Date of Receipt:	OMB No. 1205-0137 Expires: 09-30-2022

Instructions: An occupational code assignment (OCA) is a process established to help occupational information users relate a job title or occupational specialty to an O*NET-SOC occupation. The Occupational Information Network (O*NET) is a Standard Occupational Classification (SOC) based system. The information gathered during the OCA Process: 1) leads to code assignments for customers, 2) helps update the O*NET lay titles database, and 3) is considered during the O*NET-SOC occupational classification review and development. Please complete the items on the Occupational Code Assignment (OCA) Form – Part A to the best of your ability. Items 1-6 collect contact information. For items 7-20, please provide the most accurate description of the job or occupation that you are attempting to locate in the O*NET system. Once received, an occupational analyst at the National Center for O*NET Development will review your answers to OCA Form – Part A. Upon analysis, the analyst will send you an OCA Form – Part B that will list and explain the code assignment.

1. Contact Name(s) and Organization (Include name(s) of individual(s) submitting request, as well as name of organization, agency, business, etc.):	**2. Contact Address** (Include city, state and zip code):	**3. Check Appropriate Box:**
Name: Reva Singh & Tayler Williams Name: Org: American Medical Informatics Association (AMIA)	Address: 6218 Georgia Ave NW, Ste. #1 City: Washington, DC 20011 State: Zip:	Employer/Business Individual Office of Apprenticeship (OA) Foreign Labor Certification (FLC) **Other**
4. E-mail Address(es):	**5. Telephone Number(s):**	**6. Date (mm/dd/yy) Submitted:**
rsingh@amia.org twilliams@amia.org	301.657.1291 x889 240.479.2134	August 31, 2023

7. Industry (In order of importance, list the primary industry or industries where this occupation is found. Representative industries are "construction," "educational services," "manufacturing," or "retail trade." Please include NAICS code(s), if known, or describe the product or service provided by establishments that employ this type of worker)**:**

- 62 – Health Care and Social Assistance

Other areas which should be recognized, in order of "importance" include the following codes:

- 54 – Professional, Scientific, and Technical Services
- 5415 – Computer Systems Design and Related Services
- 541511 – Custom Computer Programming Services
- 5416 – Management, Scientific, and Technical Consulting Services
- 5417 – Scientific Research and Development Services
- 52 – Finance and Insurance
- 61 – Educational Services
- 611310 – Colleges, Universities, and Professional Schools
- 513210 – Software Publishers
- 524114 – Direct Health and Medical Insurance Carriers
- 45611 – Pharmacies and Drug Retailers
- 3391 – Medical Equipment and Supplies Manufacturing
- 518210 – Computing Infrastructure Providers, Data Processing, Web Hosting, and Related Service

8. Title (Please write the title of the job or occupation that you would like reviewed and assigned within the O*NET-SOC classification system.)**:**

Clinical Informatician/Informaticist

Clinical informaticians/informaticists may work in:

- Health Care Delivery Organizations
- Public Health Agencies
- Universities (Private and Public)
- Research Institutes and Organizations
- Industry, Vendors, and Consulting Firms
- Government Agencies and Entities that Support Health Research, Public Safety, and the Health Information Infrastructure
- Policy and Professional Associations, Non-Profit Collaborative Organizations, Community Groups, Foundations, NGOs
- Public and Private Payors/Insurance

Clinical informaticians/informaticists may hold titles such as:

- Chief Medical Information Officer (CMIO), Chief Health Information Officer (CHIO), Chief Clinical Informatics Officer (CCIO), Chief Nursing Informatics Officer (CNIO), Chief Pharmacy Informatics Officer (CPIO), Chief Dental Informatics Officer (CDIO)
- Physician Informaticist, Nurse Informaticist, or other clinician Informaticist
- Pharmacy Informaticist
- Research Informaticist

9. Summary Description of Job/Occupation (Summarize the overall objective or purpose of the occupation, such as "plan, direct, and coordinate training activities of an organization.")**:**
Clinical informaticians/informaticists transform health care by analyzing, designing, implementing, and evaluating information and communication systems and other innovations that enhance individual and population health outcomes, improve patient care, and strengthen the clinician–patient relationship. The role includes use of knowledge to assess impact of technology on clinician cognitive load with the aim to decrease potential burnout and improve efficiency of processes to improve the performance of the system as a whole. This work is imperative to reducing burden and clinicians leaving the workforce.

Clinical informaticians/informaticists use their knowledge of human health and illness, health care data, and healthcare systems operations combined with their understanding of informatics concepts, methods, and tools to:

- assess information and knowledge needs of health care professionals and patients;
- define requirements and conduct workflow analyses for clinical informatics initiatives;
- characterize, evaluate, and refine clinical processes and data;
- develop, implement, and refine clinical decision support systems and other innovative systems and solutions;
- lead or participate in the procurement, customization, development, implementation, management, evaluation, and continuous improvement and interoperability of clinical information systems;
- lead research in biomedical informatics and participate in research studies in collaboration with clinical scientists; and
- participate in change management, quality improvement, and patient safety efforts.
- Ensure compliance with healthcare regulations

Physicians who work in clinical informatics collaborate with other health care and information technology professionals to promote patient care that is safe, efficient, effective, timely, patient-centered, and equitable. Physician informaticians/informaticists have specialized training as a professional Medical Doctorate or Osteopathic Doctorate that enables them to bring specialized medical knowledge to the field of informatics. Physicians may be Board certified in Clinical Informatics.
(Program Requirements for Fellowship Education in the Subspecialty of Clinical Informatics – Journal of the American Medical Informatics Association, Volume 16, Issue 2, March 2009, Pages 158–166)

Nurses who are ANCC board-certified in nursing informatics require 1,000-2,000 hours of informatics nursing experience, 30 hours of continued education in informatics within the last three years, two years of full-time RN experience, and a bachelor's degree.
(Informatics Nursing Certification (RN-BC®) | ANA)

- Provides business focused management analysis support by ensuring the institution's services are well defined
- Employs a systems engineering framework in support of program management concepts and sustainment approach.
- Converges IT and business partners, reduce barriers, and shares ownership for achieving strategic outcomes.
- Experienced in health informatics and provides clinical and technical expertise to ensure delivery of high-quality informatics tools at all points in the software development life cycle from a functional (business) perspective.
- Provides expertise and guidance on health informatics clinical applications and products to support computerized patient record systems and modernized electronic health record systems.
- Analyzes and evaluates on a quantitative/qualitative basis the effectiveness of program operations in meeting established goals and objectives.
- Uses health informatics knowledge to streamline processes, influence and adapt informatics systems in the organization to drive management of the health care system toward effectiveness and efficiency.

- Possess a unique combination of nursing and informatics practice expertise.
- Have an expert understanding of health care delivery and operational flow.
- Conduct data, information, and knowledge management for individuals and populations.
- Provide informatics leadership to the organizational strategy.
- Influence healthcare policy and advocate for ethical standards and principles to be applied to technology, data, information, and
- communication solutions used by health care professionals, patients, families, consumers, and populations.
- Conduct basic and applied research to improve the design, implementation, and use of technology, data, information, and communication solutions in health care delivery.
- Incorporate sociotechnical frameworks by applying usability and design principles.
- Help design, develop, and implement learning solutions and educational programs to achieve informatics competencies and meet end-user needs.

Pharmacy informatics is the scientific field that focuses on medication-related data and knowledge within the continuum of healthcare systems – including its acquisition, storage, analysis, use, and dissemination – in the delivery of optimal medication-related patient care and health outcomes. The five key areas of responsibility are broadly information management, knowledge delivery, data analytics, clinical informatics, and change management. Within clinical informatics, pharmacists are responsible for computerized medication reconciliation and smart pump optimization, which are necessary for avoiding medication errors and reducing patient harm. (Pharmacy Informatics and Its Cross-Functional Role in Healthcare, HIMSS)

Dental Informatics has the potential to bridge the gap between clinical care delivery in dental and medical settings. A dental informaticist is responsible for leveraging technology to improve dental care and practice management. Their duties may include designing and implementing electronic health records (EHR) systems for dental practices, ensuring data security and privacy, optimizing dental workflow processes, integrating digital imaging and diagnostic tools, analyzing dental data for insights, and keeping up to date with dental and technological advancements to provide informed recommendations for enhancing patient care and practice efficiency.

10. Tasks (In order of importance, list the most important and/or regularly performed tasks for this occupation. Please use action verbs, such as "appraises and inventories real and personal property," to begin these task statements. Representative tasks are "direct safety operations in emergencies" or "prepare daily reports of fuel, oil, and accessory sales.")**:**

1. Apply their area of training and expertise to the daily tasks of informatics and clinical practice.
2. Collect, analyze, and apply data directly to care decisions that support individual patients (Clinical Decision Support, Health Maintenance) and populations (Population Health).
3. Use health data and systems to innovate care advancement.
4. Design, implement, develop information systems using informatics.
5. Research improvements to health IT to develop recommendations for application to programs or operations and support clinical research.
6. Analyze and manage information requirements to recommend program or administrative systems including the systems specifications, data gathering and source, analytical techniques, and systems evaluation methodology.
7. Analyze new or proposed legislation or regulations to determine impact on program and account for risk in planning.
8. Review existing state of business plan, and recommend changes to workflow and opportunities to gain efficiencies to facilitate adoption of health IT.
9. Act as an operations integrations manager and manages the entire product development and sustainment lifecycle and engages IT department and business subject matter experts as required to support the integration of the solution into production and ensures that project related issues are managed effectively.
10. Provide business relationship management support for assigned administrations and staff offices across the organization. In this capacity, the incumbent understands the business processes and provides technology guidance to maximize return on investment to support business partner outcomes.
11. Provide key project and program management support for electronic health record modernization and other health information management, clinical application product line programs such as bar code medication administration, and various other organizational efforts.
12. Monitor efficiency of providers for purposes of supporting physician well-being and optimizing the system for individual users.
13. Serve as liaison between business and technical components to health informatics programs and represents business owners to ensure requirements are satisfied throughout the program life cycle.
14. Responsible for independently negotiating a highly complex organizational and technical environment to accomplish organizational goals.
15. Create own plans of action, identify, and resolve risks and issues, negotiate plans and solutions with members of the senior executive team across the organization and sometimes with other agencies.

11. Work Activities (In order of importance, list the most important and/or regularly performed generalized work activities for this occupation. Representative generalized work activities are "analyzing data or information," "making decisions or solving problems," or "communicating with people outside the organization.")**:**

1. Collect, analyze, and apply data to make decisions.
2. Communicate data analysis to people within and outside of the organization.
3. Innovate to support communications between professionals including secure chat and other messaging tools.
4. Use health data and systems to innovate care advancement.
5. Design, implement, develop, and evaluate information systems using informatics principles.
6. Support change management.
7. Facilitate interoperability of data to support healthcare decision making.
8. Development and implementation of technology, data, information and communication solutions in health care delivery.
9. Development and implementation of health information systems to support patient access to healthcare.
10. Translate data to information to knowledge in a manner that supports safe and efficient clinical workflows.
11. Support and conduct research using healthcare data and other data types.

12. Interactions (List the types of people that individuals within this occupation interact with during a typical workweek. Representative interactions are "customers," "supervisor," "accountants," "lawyers," "students," "co-workers," or "patients.")**:**

- Patients/Consumers
- Business Administrators
- Families and Caregivers of Patients
- Students
- Clinical Team Members (nurses, therapists, etc.)
- Researchers
- Health Care Providers
- Health Administrators, including financial leaders, operational leaders, and executive leaders
- Co-workers/Colleagues
- Policy makers
- Legal experts
- Ethicists
- IT professionals
- Interns and Residents

13. Physical Activities (List the primary physical activities performed within this occupation. Representative physical activities are "load boxes on an assembly line," "climb up and down poles to install electricity," or "walk between work stations in a small office.")**:**

- Working with computers and smart devices
- Travel between workstations in a healthcare facility
- Engage with individuals in the healthcare and community setting

14. Knowledge Areas (In order of importance, list the knowledge or subject matter areas required to perform the tasks and responsibilities of this occupation. Representative knowledge areas are "administration and management," "mathematics," "biology," "customer or personal service", "public safety and security", or "medical terminology".)**:**

1. Health and Life Science Profession
2. Healthcare Finance
3. Health terminology
4. Mathematics, Data Science, and Computer Science
5. Data Safety and Security
6. Health
7. Public Health
8. Information Science and Technology
9. Social and Behavioral Science and Aspects of Health
10. Genetics and Genomics
11. Health Information Science and Technology
12. Human Factors and Socio-technical Systems
13. Research and Evaluation
14. Professionalism
15. Interprofessional Collaborative Practice – Coordination, Facilitation, and Integration
16. Leadership, Management and Administration
17. Clinical Informaticians/informaticists bring key knowledge from their professional degrees and licensed areas of expertise.
18. Board Certified Physician Informatician training includes key knowledge areas that can be found here: ACGME Informatics Competencies

15. Education (Please indicate the level of educational preparation typically requested or required to qualify for this occupation. The information you provide is subject to independent verification.)**:**

Formal education

Less than a High School Diploma
High School Diploma (or GED or High School Equivalence Certificate)
Post-Secondary Certificate – awarded for training completed after high school
Some College Courses
Associate's Degree (or other 2-year degree)
Bachelor's Degree

Graduate education

Post-Baccalaureate Certificate
Master's Degree
Post-Master's Certificate
First Professional Degree
Doctoral Degree
Post Doctoral Training

Indicate Field of Study: Any field of study that lends itself to performing informatics driven work

16. Training/Experience (Please indicate the training/experience typically requested or required to qualify for this occupation. Please check all boxes that apply. The information you provide is subject to independent verification.)**:**

Other: AMIA Health Informatics Certification (AHIC), FAMIA, American Board of Medical Specialties Board Certification for physician informaticists (not required, but preferred), American Board of Preventive Medicine Board Certification in Clinical Informatics, American Nurses Credentialing Center Informatics Nursing Board Certification

17. Tools or Technology Used) (In order of importance, list the machines, equipment, tools, software, and information technology or devices workers may use to perform the tasks and responsibilities of this occupation. Representative tools and technology are "lathe," "hand tools," "environmental monitoring equipment," "spreadsheet," or "software packages." You may specify by name rather than category.)**:**

- Electronic Health Records (EHR)
- Clinical Information Systems Software
- Telehealth
- Structured Query Language (SQL)
- Machine Learning
- Artificial Intelligence
- Project Management
- Information Technology Management
- Data Analytics
- Cloud Computing
- Data Visualization
- Hardware, including Mobile Devices
- Wearable Sensors
- Medical, healthcare, and personal devices
- Interoperable Apps (e.g., Smart on FHIR, Geospatial Information Systems, Open Source Technology Tools)

18. Web Sites/Resources (List web sites or other resources where information about the occupation can be found.)**:**

- AMIA - American Medical Informatics Association
  - AMIA Health Informatics Certification (AHIC)
  - Fellows of AMIA Eligibility Criteria
  - AMIA Clinical Informatics Fellows (ACIF)
- JAMIA - Journal of the American Medical Informatics Association | AMIA
- Healthcare Information and Management Systems Society | HIMSS
- Homepage | Alliance for Nursing Informatics
- U.S Department of Veteran Affairs | Informatics
- ONC | Office of the National Coordinator for Health Information Technology
  - Public Health Informatics & Technology (PHIT) Workforce Development Program | HealthIT.gov
- Become Certified – American Board of Preventive Medicine (theabpm.org)
- Association of Medical Directors of Information Systems | AMDIS
- Informatics Nursing Certification (RN-BC®) | ANA (nursingworld.org)
- Supplemental Guide: Clinical Informatics - Accreditation Council for Graduate Medical Education
- Kannry J, Sengstack P, Thyvalikakath TP, Poikonen J, Middleton B, Payne T, Lehmann CU. The Chief Clinical Informatics Officer (CCIO) 2016 Mar 16;7(1):143-76. doi: 10.4338/ACI-2015-12-R-0174. PMID: 27081413; PMCID: PMC4817341.
- Gardner RM, Overhage JM, Steen EB, Munger BS, Holmes JH, Williamson JJ, Detmer DE; AMIA Board of Directors. Core content for the subspecialty of clinical informatics. J Am Med Inform Assoc. 2009 Mar-Apr;16(2):153-7. doi: 10.1197/jamia.M3045. Epub 2008 Dec 11. PMID: 19074296; PMCID: PMC2649328.
- Valenta AL, Berner ES, Boren SA, Deckard GJ, Eldredge C, Fridsma DB, Gadd C, Gong Y, Johnson T, Jones J, Manos EL, Phillips KT, Roderer NK, Rosendale D, Turner AM, Tusch G, Williamson JJ, Johnson SB. AMIA Board White Paper: AMIA 2017 core competencies for applied health informatics education at the master's degree level. J Am Med Inform Assoc. 2018 Dec 1;25(12):1657-1668. doi: 10.1093/jamia/ocy132. PMID: 30371862; PMCID: PMC7647152.

19. Explanation of Submittal (Optional: It may be helpful to indicate the reasons you are seeking this occupational code assignment.)**:**

- Support healthcare workforce
- Support evidence-based clinical decision making
- Advance healthcare for all by supporting public health systems and delivery

20. Additional Information/Comments (List or attach any additional information or comments that may help in assigning this job or occupation to an O*NET-SOC occupation. Additional information may include items, such as on-the-job training schedules or curriculum for relevant training programs.) If this request is part of registering an apprenticeship program, please attach Work Process Schedule, if available**:**

Please review the attachments we've shared. These will help illustrate the field of clinical informatics.

Please Send Completed OCA Form – Part A to:

OCA Specialist, O*NET Project
Employment and Training Administration
U.S. Department of Labor
Mail Stop C4526
200 Constitution Avenue, N.W.
Washington, D.C. 20210
E-mail: oca@onetcenter.org

The National Center for O*NET Development will process your request within 14 business days. If we need additional information to process your request, we will contact you based on the contact information you provided on the OCA Form – Part A. After completing our analysis of your request, we will send you an OCA Form - Part B that will list and explain the code assignment.

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AMIA Position Paper

AMIA Position Paper

Domains, tasks, and knowledge for health informatics practice: results of a practice analysis

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The AMIA Board of Directors formally approved this paper on 16 November 2019.

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ABSTRACT

Objective: To develop a comprehensive and current description of what health informatics (HI) professionals do and what they need to know.

Materials and Methods: Six independent subject-matter expert panels drawn from and representative of HI professionals contributed to the development of a draft HI delineation of practice (DoP). An online survey was distributed to HI professionals to validate the draft DoP. A total of 1011 HI practitioners completed the survey. Survey respondents provided domain, task, knowledge and skill (KS) ratings, qualitative feedback on the completeness of the DoP, and detailed professional background and demographic information.

Results: This practice analysis resulted in a validated, comprehensive, and contemporary DoP comprising 5 domains, 74 tasks, and 144 KS statements.

Discussion: The HI practice analysis defined "health informatics professionals" to include practitioners with clinical (eg, dentistry, nursing, pharmacy), public health, and HI or computer science training. The affirmation of the DoP by reviewers and survey respondents reflects the emergence of a core set of tasks performed and KSs used by informaticians representing a broad spectrum of those currently practicing in the field.

Conclusion: The HI practice analysis represents the first time that HI professionals have been surveyed to validate a description of their practice. The resulting HI DoP is an important milestone in the maturation of HI as a profession and will inform HI certification, accreditation, and education activities.

Key words: health informatics, practice analysis, delineation of practice, certification, workforce development

INTRODUCTION

Health informatics (HI) professionals analyze, design, implement, and evaluate information systems to improve clinical and public health processes and outcomes, enhance patient and health professional interactions with the health system, and strengthen the ability of communities and individuals to manage their health. Health informatics encompasses clinical informatics broadly defined, public health informatics, and consumer health informatics. Health informatics professionals come from a range of educational and training pathways including, but not limited to, dentistry, medicine, nursing, pharmacy, public health, health informatics, and computer science.

The HI field is young and dynamic. Its evolution mirrored dramatic changes in both healthcare and computer science over its first 70 years.[1] The past decade has been notable for increased demand for individuals who could help healthcare organizations navigate the federal government's requirements for electronic health records.[2] This period has also seen growth in applied HI education programs

and recognition among HI professionals that there is a body of knowledge to be mastered for proficient practice.[3,4] In short, the applied informatics workforce has been growing and the HI profession is becoming increasingly formalized.

Since 2005, the American Medical Informatics Association (AMIA) has been working to ensure that the informatics profession evolves in ways that are responsive to the needs of individual practitioners, the organizations that hire them, and the larger health system. Specifically, AMIA established the informatics professional code of conduct, led the effort to establish and continues to support the clinical informatics subspecialty (CIS) for physicians, developed the core competencies that are being used for accreditation of HI master's degree programs, and is working to establish HI certification for individuals who are not eligible for the CIS.[4–8]

As part of the effort to establish HI certification, AMIA conducted a formal practice analysis of HI. Practice analysis, sometimes called job or task analysis, "is the systematic definition of the components of work and essential knowledge, skill, and other abilities at the level required for competent performance in a profession, occupation, or role."[9] Conducting a rigorous practice analysis provides a direct link between what professionals do and how their competence is assessed for certification and is integral to the development and operation of high-stakes professional certification programs. Two key elements of this methodology include 1) a structured consensus process to develop a delineation of the practice (DoP) in terms of domains, tasks, and knowledge and skills (KSs) and 2) a survey of active professionals to determine how well the DoP describes their practice. Practice analysis is a widely recognized strategy for delineating a comprehensive and contemporary profile of practice in a profession and establishing the content validity of a credentialing program.

The HI practice analysis study closely followed the processes AMIA used for the CIS practice analysis.[7] The structure of this article largely parallels that of the CIS article to facilitate comparison of the processes and results of the 2 studies.

MATERIALS AND METHODS

Objective

This project sought to develop a robust, relevant, and contemporary HI DoP in terms of domains, tasks, and KSs to inform development of AMIA's HI certification program, support AMIA educational programming, and provide insights to HI educators.

Project organization

AMIA contracted with a nonprofit consulting organization with extensive credentialing advisory services experience. The consultants planned and led all meetings, managed the peer review process, performed all qualitative and quantitative data collection and analyses, and facilitated discussion and approval of the analyses and results by the Practice Analysis Task Force (PATF) and oversight panel (see below).

AMIA established a 9-member oversight panel representing different primary health domains and AMIA leadership (see Box 1). This group was responsible for articulating the vision and goals for the practice analysis process, providing guidance to the

Box 1. Health Informatics practice analysis oversight panel and task force members*

Oversight Panel (OP)
Douglas B. Fridsma, MD, PhD, AMIA
Cindy Gadd, PhD, MBA, MS, AMIA, Vanderbilt University
Joe Hales, PhD, Intermountain Healthcare
Jim Jellison, MPH, Public Health Informatics Institute
Scott Nelson, PharmD, MS, Vanderbilt University Medical Center
Sarah Collins Rossetti, PhD, RN Columbia University Medical Center
Elaine B. Steen, MA, AMIA
Richard Tayrien, DO, Center for Medical Interoperability
Jeffrey J. Williamson, MEd, AMIA

Practice Analysis Task Force (PATF)
Anisha Abdul-Ali, DNP, MPH, RN, OCHIN
Cindy Gadd, PhD, MBA, MS, AMIA, Vanderbilt University
Peter Hicks, MPH, MA, Centers for Disease Control
Donald (Chuck) Kowalewski, DO, FACOI, Orlando VA Medical Center
Laura Heerman Langford, PhD, RN, Intermountain Healthcare
Brian LeBaron, PharmD, BCPS, Southeast Louisiana Veterans Health Care System
Lisa Lyon, MHI, BSN, Cherokee Nation Health Services
Sharon Perelman, DDS, Columbia University College of Dental Medicine
Sarah Collins Rossetti, PhD, RN, Columbia University Medical Center
Gerardo Soto-Campos, PhD, MS, Virtual Pediatric Systems, LLC
Dennis Tribble, PharmD, FASHP, BD
Nicole Willis, MPH, North Sound Accountable Community of Health
Deborah Woodcock, MBA, Oregon Health and Science University

*=Affiliations listed are those at time of practice analysis

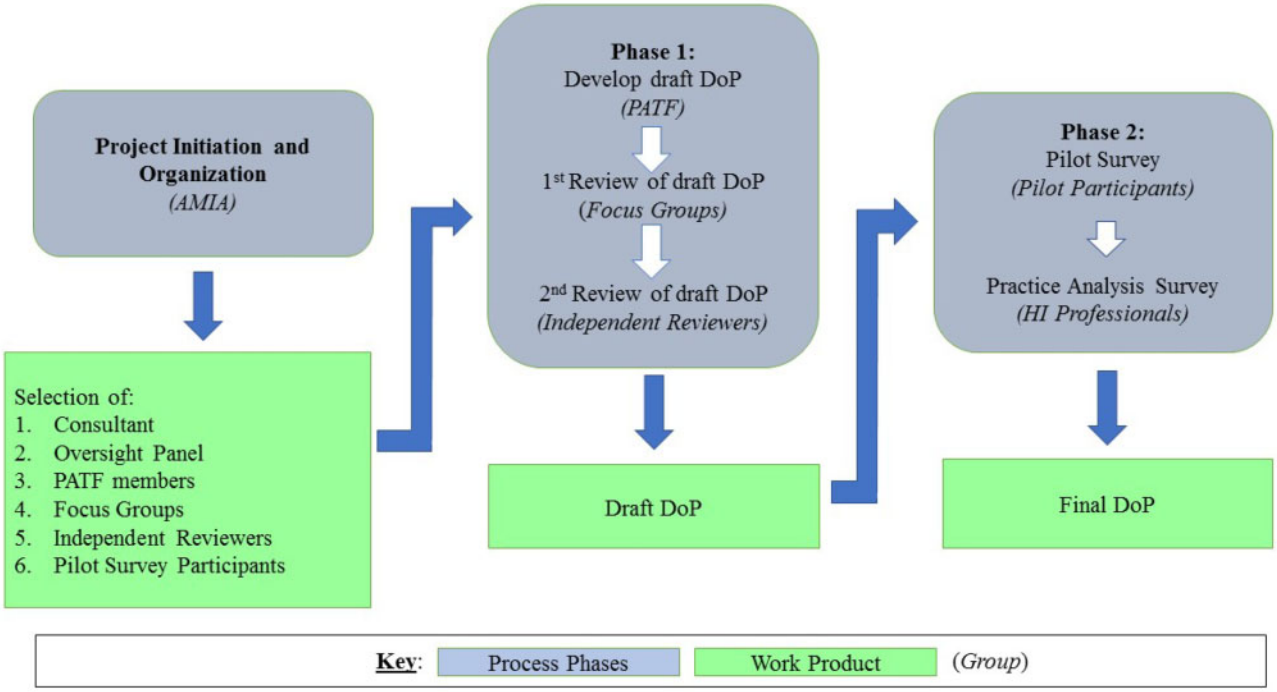

Figure 1. Overview of health informatics (HI) practice analysis processes, workflows, and work products. DoP: delineation of practice; PATF: practice analysis task force.

PATF, and ensuring that the practice analysis aligned with project objectives.

To obtain input from a wide range of HI practitioners, AMIA invited HI professionals to indicate interest in serving in 1 of 6 subject matter expert groups convened during the practice analysis. A subgroup of the oversight panel reviewed all volunteer profiles and developed rosters that were representative of the HI community (eg, primary health domain, practice setting, years of experience, geographic location) (see Figure 1). The 13-member PATF was responsible for performing the work of the practice analysis as described below (see Box 1). Forty-four additional subject matter experts contributed to the HI practice analysis by participating in 1 of 3 focus panels (19), as independent reviewers (14), and as pilot survey participants (11).

The practice analysis was conducted from April 2018 through January 2019 and was divided into 2 phases. In the first phase, the PATF developed a draft DoP; in the second phase, HI professionals validated the DoP and identified any missing components via an online survey (see Figure 1).

Phase 1: Developing the draft DoP

To inform PATF deliberations, AMIA staff compiled briefing materials on activities related to the HI practice analysis (including the CIS DoP and HI master's degree program competencies).[4,7,10] In addition, the consultants analyzed more than 80 HI job descriptions submitted by HI professionals to identify the HI tasks, competencies, and KSs sought by employers. The PATF was charged with developing a comprehensive HI DoP that was broadly applicable across primary health domains, practice settings, roles, and experience levels. The PATF was advised that their work should be not be constrained by existing materials.

During a 2-day PATF meeting, the consultants facilitated a series of large and small group activities that enabled participants to identify 1) the major domains of HI practice, 2) specific tasks performed by HI professionals, and 3) KSs required for performance of these tasks. Following the meeting, PATF members met virtually in their small groups to continue articulating the tasks and KSs for each of the domains. The consultants and AMIA staff integrated the small groups' output to create the first HI DoP draft.

To gather feedback on the draft HI DoP, the consultants conducted 3 focus panels, each populated by a specific cohort of HI professionals—practitioners, supervisors/hiring managers, and educators. Participants received the draft DoP and a list of discussion topics prior to the sessions. Focus panelists indicated that the domain structure was logical and comprehensive and well represented health informaticians across the range of health disciplines and practice settings. They suggested some revisions to enhance clarity, emphasize certain content, or reorder some tasks. The PATF used their feedback to refine the DoP.

Subsequently, independent reviewers assessed whether the draft DoP provided a clear, comprehensive, and contemporary description of HI practice (see Figure 1). Oversight panel and PATF members were also invited to participate in this review. During four 2-hour virtual meetings, the PATF considered each comment and reached consensus on revisions to the draft DoP.

Phase 2. Practice analysis survey

In the second phase of the study, the consultants developed, piloted, and administered an online survey to determine if the draft DoP accurately and comprehensively described the work of practicing HI professionals. After a 1-week pilot period, the oversight panel finalized the survey based on pilot participant feedback. The final survey was open for 3½ weeks.

AMIA sought to achieve broad representation of HI professionals among survey respondents. A total of 8057 email invitations were sent to current AMIA members, recently lapsed AMIA

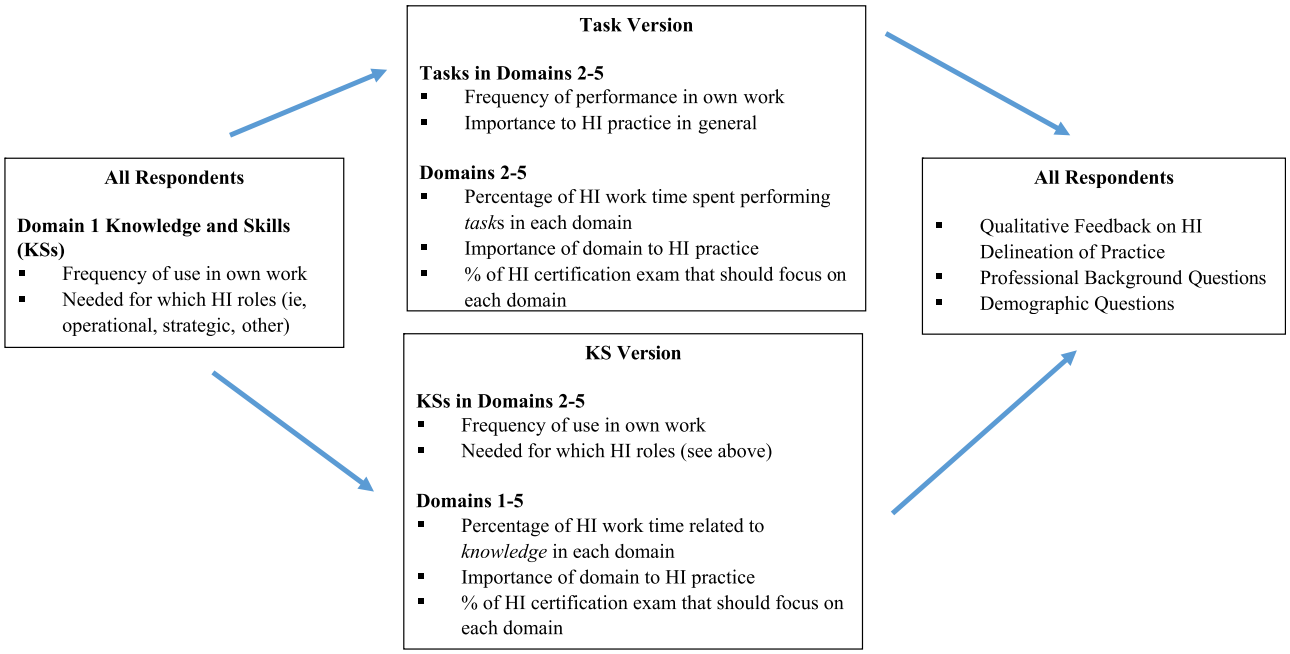

Figure 2. Overview of the health informatics (HI) practice analysis survey structure and rating scales used for domains, tasks, and KSs.

members, and individuals who had attended AMIA conferences. AMIA also obtained agreements from organizations representing imaging, nursing, osteopathy, pathology, public health, health information management, and federal health agencies to forward the survey invitation to their members. As a result, an unknown number of survey links were disseminated by these organizations. See Supplementary Appendix 1 for a list of the organizations that assisted in distributing the survey.

Figure 2 presents the survey structure and rating scales used to quantify the work performed by HI professionals. Respondents were randomly routed to 1 of 2 versions of the survey to reduce survey completion time (see Figure 2). All respondents provided qualitative feedback on the completeness of the DoP, including open-ended questions on missing domains, tasks, or KSs, and completed a professional background and demographic questionnaire.

Survey analysis methodology

Cronbach's alpha (α) was calculated to measure internal consistency and scale reliability for the frequency and importance rating scales. Frequency distributions and descriptive statistics were calculated for all ordinal (frequency, importance) and ratio (percentage of time) scales. For the KS needed by scale wherein respondents indicated the type(s) of HI professionals that needed each KS (a nominal variable permitting multiple responses), a frequency distribution of responses was calculated.

Mean values were generated for frequency and importance ratings by assigning numerical values to each response option as follows: for frequency 1 = *never*, 2 = *rarely (less than once each month)*, 3 = *occasionally (about weekly to monthly)*, 4 = *frequently (several times each week)* and 5 = *very frequently (daily/many times each day)*; for importance 1 = *not important*, 2 = *minimally important*, 3= *moderately important*, and 4 = *highly important*. For example, a mean frequency rating of 3.5 indicates that respondents performed the task or used the knowledge, on average, occasionally to frequently. Likewise, a mean importance rating of 3.2 indicates that a task was at least moderately important to HI practice.

Subgroup analyses based on 5 factors (primary discipline, practice setting, years of HI experience, career stage, and time spent in a strategic role) were performed to explore differences in practice based on these characteristics.

The PATF reviewed the results of the validation survey during a virtual meeting and used group consensus to develop recommendations regarding the final DoP. The oversight panel reviewed and affirmed the PATF recommendations.

RESULTS

The draft DoP developed and refined during phase 1 comprised 5 domains of HI practice, 144 KS statements associated with domains 1–5, and 74 task statements associated with domains 2–5 (note: domain 1 included foundational knowledge but no tasks). See Box 2 for the HI Domains of Practice and domain definitions.

Survey responses

A total of 1011 respondents completed the survey. Of these, 516 respondents (51%) entered the survey after receiving a customized emailed invitation and 495 respondents (49%) entered the survey using a link from a partner organization. Of the 8057 emailed invitations, 63 were undeliverable due to invalid addresses, and an additional 44 respondents were classified as ineligible based on their responses to screening questions. Due to the survey distribution methods, it was not possible to calculate survey response rate for the total sample. Approximately half the respondents completed each version of the survey (tasks = 500; KS = 511). The number of responses was sufficient to meet requirements for conducting statistical analyses and exceeded the threshold of 367 suggested by a sample size calculation using a margin of error of +/− 5% and a 95% confidence level.[11]

Box 2. Health Informatics domains of practice

Domain 1: Foundational Knowledge

Fundamental knowledge and skills that provide health informaticians with a common vocabulary, basic knowledge across all health informatics domains, and understanding of the environment in which they function.

Domain 2: Enhancing Health Decision-making, Processes, and Outcomes

Support and enhance decision-making by clinicians, patients, and public health professionals; analyze existing health processes and identify ways that health data and health information systems (HIS) can enable improved outcomes; evaluate the impact of HIS on practice; pursue discovery and innovation in HIS and informatics practice.

Domain 3: Health Information Systems

Plan, develop or acquire, implement, maintain, and evaluate health information systems that are integrated with existing information technology systems across the continuum of care, including clinical, consumer, and public health domains, while addressing security, privacy, and safety considerations.

Domain 4: Data Governance, Management, and Analytics

Establish and maintain data governance structures, policies, and processes. Acquire and manage health-related data to ensure its quality and meaning across settings and to utilize it for analysis that supports individual and population health and drives innovation.

Domain 5: Leadership, Professionalism, Strategy, and Transformation

Build support and create alignment for informatics best practices; lead health informatics initiatives and innovation through collaboration and stakeholder engagement across organizations and systems.

See Supplementary Appendix 2 for complete delineation of practice.

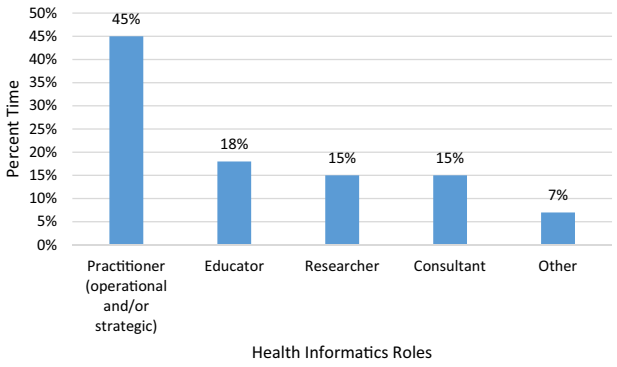

Figure 3. Percent of time spent by survey respondents in various health informatics roles.

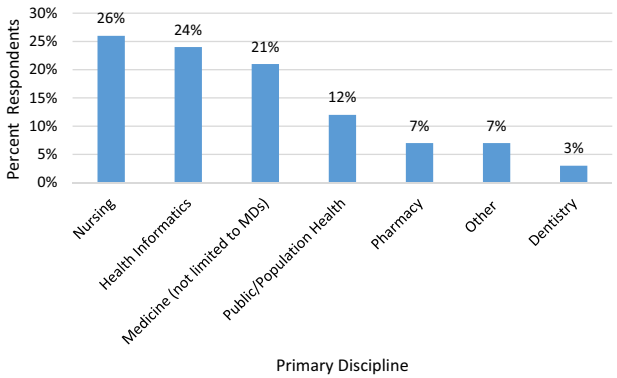

Figure 4. Primary discipline of survey respondents.

Demographic and professional characteristics of respondents

Respondents had an average of 10.8 years of HI experience and spent an average of 82% of their work time directly related to HI; nearly half (49%) spent 100% of their work time in HI. Figures 3–5 present survey respondents' time spent in different HI roles, primary discipline, and primary work setting. Wide ranges in the average percentages of time spent in each role (shown by the large standard deviations in responses) suggest that some individual respondents spend the majority of their HI work time in 1 or 2 roles, while others spend time in 3 or more roles. Nearly half (48%) of respondents had a terminal doctoral degree, 36% had a terminal master's degree, and 16% had a terminal bachelor's degree. Forty-eight states plus the District of Columbia were represented in the survey; 52 respondents worked outside the US. See Table 1 for details of the demographic characteristics of respondents.

Comparable workforce data is not available to support a rigorous comparison of survey respondents to the general population of HI professionals across the range of health domains, work settings, and areas of focus. After reviewing respondent data related to the 18 professional and demographic background variables, the PATF concluded that the relevant characteristics of survey respondents were generally representative of the broader population of HI professionals, and therefore, results could be generalized to make decisions about the delineation of practice.

Refining the dataset for analysis

To ensure that the results reflect the work of HI professionals who are practicing primarily in an applied (ie, operational or strategic) role, the dataset was filtered in advance of calculating the domain, task, and KS ratings. Fifty-one responses were removed because the respondents either spent less than 10% of their total work time in an HI role, or they spent more than 90% of their HI work time in research, education, or a combination of research and education roles. Nine hundred sixty respondents were retained for subsequent analyses.

Domain ratings

As shown in Table 2, respondents spent significant amounts of their HI work time in each of the domains, attesting to how well the

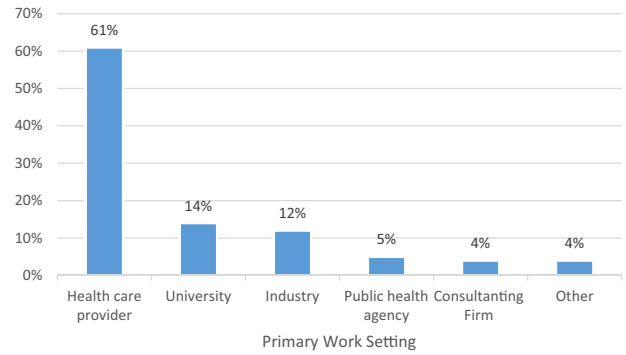

Figure 5. Primary work setting for survey respondents.

Table 1. Demographic characteristics of survey respondents

	n	%
Age		
25–34 y	108	10.7%
35–44 y	213	21.1%
45–54 y	284	28.1%
55–65 y	271	26.8%
65 y or older	67	6.6%
I prefer not to answer	38	3.8%
Missing	30	3.0%
Gender		
Female	547	54.1%
Male	398	39.4%
Do not identify as female or male	1	0.1%
I prefer not to answer	36	3.6%
Missing	29	2.9%
Race/ethnicity		
American Indian or Alaska Native	5	0.5%
African-American or Black	43	4.3%
Asian	124	12.3%
Caucasian/White	713	70.5%
Hispanic, Latino, or Spanish origin	38	3.8%
Native Hawaiian or Other Pacific Islander	3	0.3%
Some other race, ethnicity, or origin	8	0.8%
I prefer not to answer	71	7.0%
Missing	6	0.6%

domain structure reflects HI practice. Task version respondents reported, on average, that 3% of their HI work time focuses on tasks in some other HI domain. PATF members reviewed all write-in responses for other HI domains and determined these activities were already covered by the delineation or are not specific to HI practice, further attesting to the completeness of the domains. Mean domain importance ratings were equally strong from respondents routed to both survey versions, ranging from 3.6 to 3.7 across the domains on a 4-point scale. The future health informatics certification governing body will use the survey data on estimated percentages of an HI certification exam that should focus on each domain of practice to establish exam specifications.

Task ratings

Of the 960 respondents, 483 completed the task version of the survey (50%). The Cronbach's alpha value exceeded 0.97 for both task ratings scales: frequency (α 0.975) and importance (α 0.977). With respect to task frequency ratings, of the 74 tasks, 10 tasks had mean frequency ratings of 3.5 or higher (performed at least occasionally to frequently); 32 tasks had mean ratings from 3.0 to 3.4 (performed at least occasionally); and 32 tasks had mean ratings below 3.0 (performed less than occasionally). With respect to importance, 73 of the 74 tasks had mean importance ratings of 3.0 or higher (at least moderately important), and 1 task received a mean importance rating of 2.9, just below this threshold.

Table 2. Percent of time survey respondents reported spending in each domain by survey version

	% Time reported	
Domain	KS version	Task version
1: Foundational Knowledge	16.8%	Not applicable
2: Enhancing Health Decision-making, Processes, and Outcomes	22.3%	24.3%
3: Health Information Systems	22.3%	24.8%
4: Data Governance, Management, and Analytics	17.5%	22.6%
5: Leadership, Professionalism, Strategy, and Transformation	21.2%	25.4%
Other	Not applicable	2.9%

Note: See Figure 2 for survey version details.

Knowledge and skills ratings

Four hundred seventy-seven respondents completed the KS version of the survey (50%). Cronbach's alpha was calculated for the KS frequency rating scale; the reliability for this scale was (α 0.986). Of the 144 KSs, 33 received mean frequency ratings above 3.5, 54 received mean frequency ratings of 3.0 to 3.4; 43 received mean frequency ratings of 2.5 to 2.9; and 14 received mean frequency ratings below 2.5. With regard to what KSs are needed by different type(s) of HI professionals, 132 KSs were identified by at least 90% of respondents as being needed by 1 or more types of HI professionals (operational, strategic, or other). The remaining 12 KSs were identified by at least 83% of respondents as being needed by 1 or more HI professionals.

Subgroup analyses

Subgroup size varied considerably (eg, from 14 to 124 respondents for primary discipline categories). Domain importance ratings and percentage of time spent were generally consistent across all subgroups. In a small number of instances, domain percentage of time ratings varied up to 10% among respondents in different primary health domains and career stages. Regarding tasks, importance ratings were generally similar across all subgroups. Nonsystematic differences in task frequency ratings of > 0.5 on a 5-point scale were observed in a small number of tasks that were related to primary health domain and work setting. For a small number of KSs, nonsystematic differences in frequency ratings of > 0.5 on a 5-point scale were observed related to primary health domain, practice setting, years of experience, career stage, and level of strategic involvement.

Validation decisions

Using content validity as a guiding principle for validating the DoP, the majority of tasks (69 of 74) were rated high enough to warrant automatic inclusion.[12,13] These tasks received mean frequency ratings of 2.5 or higher (performed at least rarely to occasionally) and

mean importance ratings of 3.0 or higher (at least moderately important). The remaining 5 tasks received lower mean ratings and required additional discussion prior to final validation. The PATF and oversight panel reviewed the 5 tasks to determine if they should be retained in the DoP. They considered if the low frequency ratings were reasonable given the nature of the task; the low frequency ratings were balanced by high importance ratings; the task described recent key trends and changes in HI practice that may not yet have been universally adopted; the task is important for the subgroup of more advanced HI professionals. Using these criteria, PATF and oversight panel members agreed that all of these tasks were valid for inclusion in the final DoP.

Similarly, the majority of KSs (130 of 144) received clear enough validation evidence to warrant automatic inclusion in the DoP. These KSs received mean frequency ratings of 2.5 or higher (used at least rarely to occasionally) and mean importance ratings of 3.0 or higher (at least moderately important). The remaining 14 KSs received lower ratings and required additional discussion by the PATF and oversight panel to make final validation decisions. Upon review, all 14 KSs were deemed valid for inclusion in the DoP based on 1 or more of the following factors: the KS was specifically needed by those in either an operational or a strategic role; or the KS supported emerging tasks or represented new or innovative knowledge areas or techniques. Further, the PATF and oversight panel members compared the percentage of respondents who never use the KS to the percentage of respondents who say the KS is not needed by any HI professionals and found that respondents were more likely to not use a KS themselves than they were to indicate the KS is not needed by any HI practitioners. During the review process, minor edits were made to 3 KSs (K60, K116, and K126) so they more accurately reflect HI work within the context of the domains in which they appeared. The complete validated DoP is available in the Supplementary Appendix 2, and comprises 5 domains, 74 tasks, and 144 KS statements.

Completeness of the DoP

Respondents were asked how well the domains, tasks, and KSs described HI practice. Sixty percent said well or very well, 36% said adequately, and only 4% said poorly. Respondents were invited to identify aspects of the health informatician role they considered missing from the survey. PATF members reviewed each write-in response and determined that all suggestions were already incorporated in the delineation or were not specific to HI practice.

DISCUSSION

The HI practice analysis represents the first time that HI professionals have developed and validated a description of their practice. The resulting HI DoP constitutes a comprehensive and contemporary description of what HI professionals do and what they need to know. The HI practice analysis survey data and DoP provide needed information for AMIA to establish HI certification.

Beyond certification, the HI practice analysis structure and results reflect the evolution of HI as a profession. Specifically, the HI practice analysis focus on applied HI practice reflects the shift from a primarily research-oriented discipline to one comprising both researchers and growing numbers of practitioners. The broad definition of "health informatics" reflects the diversity of training and perspectives that come together in HI practice. The PATF's ability to reach consensus on a draft HI DoP and the subsequent affirmation by reviewers and survey respondents highlight the common ground in HI practice.

Analysis of professional subgroups found consistency in importance ratings for domains and tasks, and nonsystematic differences in time spent in a domain and frequency in performing a task or using a KS. Given the range of roles HI professionals perform, some variation in time spent in domains or task/KS frequency can be expected. While the small number of respondents in some subgroups prevents drawing firm conclusions about differences in practice across subgroups, the importance ratings suggest that even if some respondents do not spend as much time in a domain, perform a specific task, or use a particular KS, they recognize its value to HI practice.

The nature of the HI workforce created challenges for this practice analysis. There are no definitive data on the size of the HI workforce. It comprises individuals coming from a broad spectrum of educational paths, working in a wide array of settings, serving in a range of roles, at different career stages, and represented by multiple professional associations. The HI practice analysis sought to address the lack of a well-identified target survey population by using multiple representative groups in the development and review of the HI DoP and through the survey communication strategy that engaged other organizations to promote the HI practice analysis survey. While this approach yielded a sufficient number of survey respondents to achieve confidence in the results, it is impossible to calculate the response rate because the number of individuals who received the survey link is unknown. Survey respondents were almost equally divided between those who received the survey link due to an AMIA connection and those who received the link from other sources. This result suggests that the practice analysis results are not AMIA-centric and are reflective of the broader HI workforce.

The HI practice analysis presents a snapshot of the applied HI workforce. Future efforts to characterize the HI workforce would be aided greatly by the creation of federal Standard Occupational Classification (SOC) codes that accurately describe HI professionals.[14] The HI DoP could inform future SOC updates. AMIA will also develop an informatics career framework to capture additional dimensions of the HI workforce such as work settings, roles, titles, and experience level.

Two documents informed the HI practice analysis and will have an ongoing relationship with the HI DoP: the CIS DoP and the core competencies for applied HI education at the master's degree level.[4,7] The CIS DoP was created using a process similar to that of the HI practice analysis, but focused on describing the practice of CIS physicians. Despite the broader range of HI, the 2 DoPs include similar domain structures and many of the same tasks and KSs. This suggests that there is an identifiable common body of knowledge and skills for CIS and HI professionals.

The HI DoP is a critical part of both accreditation and certification activities. The Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM) adopted the core competencies for applied HI education at the master's degree level for accreditation of HI master's degree programs. In the near term, there is a need to harmonize the HI core competencies and the HI DoP so that educational programs and students have a clear understanding of how the content in the 2 documents relate. In the longer term, the HI DoP may inform future versions of the core competencies for HI master's level educational programs, as well potential new accreditations (eg, at the bachelor's or doctoral level). Finally, the HI DoP will inform the examination for a HI certification program.

Health informatics is a dynamic field that responds to changes in technology, policy, and innovations in healthcare delivery and

public health. As a result, it will be necessary to perform periodic practice analysis studies to ensure the HI DoP remains current. If there are significant changes in HI practice in a short timeframe, AMIA can use interim data collection procedures such as focus panels or mini-surveys to ensure that no part of the DoP becomes obsolete and no significant changes in practice are overlooked.

CONCLUSION

The HI practice analysis constitutes a milestone in the maturation and formalization of HI as a profession. The resulting HI DoP provides a data-driven description of HI practice that will inform future certification activities, accreditation requirements for HI education programs, educational programming, job descriptions, performance evaluations, and possibly career choices.[15] By highlighting the nature of HI work and the functions required by employers, the HI DoP points to the need for increased attention to workforce development and cultivating a pipeline at earlier levels of education. At a more fundamental level, the HI practice analysis and the resulting DoP revealed the core of applied HI practice. We now know what HI professionals from different primary disciplines, working in a range of settings, in various roles, and with different experience levels share in terms of knowledge and skills, the work they do, and the unique set of abilities they bring to the challenges of improving health and healthcare.

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AUTHOR CONTRIBUTIONS

Each of the authors (CG, ES, CC, SG, JW, DF) contributed substantially to the article as follows:

1. Substantial contributions to the conception or design of the work or the acquisition, analysis, or interpretation of data for the work;
2. Drafting the work or revising it critically for important intellectual content;
3. Final approval of the version to be published;
4. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Journal of the American Medical Informatics Association* online.

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CONFLICT OF INTEREST

The authors have no competing interests to declare.

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Perspective

Perspective

AMIA Board White Paper: AMIA 2017 core competencies for applied health informatics education at the master's degree level

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ABSTRACT

This White Paper presents the foundational domains with examples of key aspects of competencies (knowledge, skills, and attitudes) that are intended for curriculum development and accreditation quality assessment for graduate (master's level) education in applied health informatics. Through a deliberative process, the AMIA Accreditation Committee refined the work of a task force of the Health Informatics Accreditation Council, establishing 10 foundational domains with accompanying example statements of knowledge, skills, and attitudes that are components of competencies by which graduates from applied health informatics programs can be assessed for competence at the time of graduation. The AMIA Accreditation Committee developed the domains for application across all the subdisciplines represented by AMIA, ranging from translational bioinformatics to

clinical and public health informatics, spanning the spectrum from molecular to population levels of health and biomedicine. This document will be periodically updated, as part of the responsibility of the AMIA Accreditation Committee, through continued study, education, and surveys of market trends.

Key words: professional competence, professional practice, education, graduate, accreditation, curriculum

INTRODUCTION AND BACKGROUND

In 2012, a committee of the AMIA Academic Forum published as an AMIA Board White Paper the definition of biomedical informatics and specification of core competencies for graduate education in the discipline.[1] The White Paper drew on a series of task force meetings with stakeholders and sought to provide broad competency statements that programs could use in curriculum and course development.

Recognizing the importance of supporting the emerging profession of health informatics, in January 2015, AMIA joined the Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM) as an Organizational Member to work on one aspect of a maturing profession: accreditation.[2] CAHIIM is an independent accrediting organization whose mission is to serve the public interest by establishing and enforcing quality accreditation standards for health informatics (HI) and health information management (HIM) educational programs.

AMIA and CAHIIM began working together on an update of accreditation standards for professionals in applied health informatics at the master's degree level. The collaboration sought to move from an accreditation model of standards driven by curriculum content to a model driven by attainment of competence. AMIA and CAHIIM agreed that the foundation for the new model should be based on the 2012 White Paper. To accomplish this goal, two separate committees were created. AMIA worked with CAHIIM to establish the Health Informatics Accreditation Council (HIAC) and AMIA established the AMIA Accreditation Committee (AAC).

Health Informatics Accreditation Council

The HIAC was initially charged with updating the existing CAHIIM Curriculum Requirements document and the CAHIIM *2010 Standards and Interpretations for Accreditation of Master's Degree Programs in Health Informatics* (http://www.cahiim.org/documents/2012_HI_Masters_Stndrds.pdf). The Curriculum Requirements were to be reframed as new graduate outcome "Health Informatics Competencies" and were to be formally referenced within the curriculum section of the CAHIIM accreditation standards so as to reflect the emergent knowledge, skills, and attitudes associated with the foundational domains for health informatics. It is the role of HIAC within CAHIIM to:

1. Review and revise accreditation standards in conjunction with the CAHIIM board of directors;
2. Establish decisions for accreditation action, based on review of the documentation provided by programs and site visits;
3. Report accreditation decisions to the CAHIIM board;
4. Review outcome reports and dashboard data from CAHIIM staff; and
5. Oversee peer reviewers who serve the council.

AMIA Accreditation Committee

The AMIA AAC (a subcommittee of the AMIA Education Committee) is to serve as the primary interface between AMIA and CAHIIM to achieve the goals of participation by AMIA in CAHIIM and the HIAC. The AAC was charged with establishing a set of foundational domains that reflected the intent of the 2012 White Paper and an outline of competencies to guide graduate programs seeking accreditation. It is the role of AAC within AMIA to:

1. Provide validation examples and guidelines to assist programs in interpreting domains and competencies;
2. Collaborate in monitoring and refining domains and competencies to keep them current;
3. Provide guidelines to assist programs in interpreting domains for competency-driven curricula;
4. Collaborate for the purpose of coordination and communication across health informatics education-focused groups;
5. Help identify educational activities that can assist academic programs through shared ideas for curriculum evaluation and student assessment as it relates to the foundational domains; and
6. Maintain/update the foundational domains and core competencies.

ESTABLISHING THE FOUNDATIONAL DOMAINS FOR HEALTH INFORMATICS EDUCATION

In reviewing the CAHIIM *2010 Standards and Interpretations for Accreditation of Master's Degree Programs in Health Informatics* to begin its update, HIAC found the curriculum requirements aligned with the 2012 White Paper, yet the requirements had become somewhat dated, were difficult to interpret, lacked specifics on the depth of instruction, and focused on content of the curriculum rather than the expected competence to be demonstrated by a graduate with a master's degree in Health Informatics. While the White Paper described a core set of competencies that were shared by many informatics subdisciplines, the broadly stated competencies were not sufficiently succinct for use in a formal accreditation process.

The updated accreditation standards related to curriculum sought to provide a framework to define HI competencies broadly enough to be applicable to a wide variety of established programs. Additionally, the scope of the discipline, and, therefore, the curriculum standards, needed to span the spectrum from translational bioinformatics to public health, including clinical informatics, consumer health informatics, and clinical research informatics. As a general guideline, AMIA and CAHIIM agreed that the new framework should define roughly 10 areas of competence.

In 2015, a task force that was a subgroup of HIAC (Johnson, Boren, and Tusch) created an initial vision for HI competencies. The HIAC task force analyzed the 5 broad areas defined in the AMIA White Paper: 1) professional skills; 2) scope and breadth of discipline; 3) theory and methodology; 4) technologic approach; and 5) human and social context. The task force began by reorganizing the content in areas 2 to 5, drawing on related publications.[3–6] The outcome of this work was a Venn diagram with 3 intersecting circles corresponding to the broad "parent" disciplines that inform health informatics: health science, information science, and social science.

Table 1. Timelines for establishing AMIA foundational domains

Time Period	Committee/Organization	Deliverable/Activity
2015	HIAC Task Force	1. Venn diagram describing 7 foundational domains 2. Venn diagram describing 7 professional skills
April 2015	HIAC - CAHIIM	Model of Venn diagrams presented at AMIA Academic Forum
October 2015	HIAC – CAHIIM	Model of Venn diagrams presented during an AMIA webinar
November 2015	HIAC – CAHIIM	Model of Venn diagrams and accreditation process overview presented at AMIA Annual Symposium
March 18, 2016	HIAC—AAC—AMIA Leadership	Committee charters discussed; transition of work effort from HIAC to AAC
April 2016	AAC	AAC model, reducing HIAC model to 10 foundational domains
June 2016	AAC	First draft of AMIA domains presented at AMIA InSpire Conference
September 14 – October 14, 2016	AAC and members of AMIA leadership	AMIA foundational domains and examples of key aspects of competencies disseminated for public comment to Academic Forum and AMIA community
November 2016	AAC and members of AMIA leadership	AMIA foundational domains and examples of key aspects of competencies incorporate both stakeholder and public comments
December 2016	AMIA Board of Directors	Final version of AMIA foundational domains and examples of key aspects of competencies submitted and approved by email vote
January 12, 2017	AMIA Board of Directors	*AMIA 2017 Core Competencies for Health Informatics Education at the Master's Degree Level* formally accepted by vote of the Board
January 2017	HIAC	Newly approved *AMIA 2017 Core Competencies*. . . embedded in CAHIIM revised *2017 Standards for Accreditation of Master's Degree Programs in Health Informatics*
March 2017	CAHIIM	*2017 Standards for Accreditation*. . . disseminated for public comment
June 2017	CAHIIM	*2017 Standards for Accreditation*. . . approved by CAHIIM Board

The regions of intersection among the circles produced 7 distinct combinations: health science, information science, social science, health information science, social health science, social information science, and social health information science.

In analyzing the remaining area from the AMIA White Paper (professional skills), the HIAC task force was influenced by the Health Leadership Competency Model™ of the National Center for Healthcare Leadership, which is also represented by a Venn diagram of 3 intersecting circles.[7,8] The team adapted this model to produce a second Venn diagram with 7 regions, which were labeled analyze, execute, communicate, manage, conduct, collaborate, and lead, drawing on related literature.[9,10] The skill for lead was defined broadly to include many forms of leadership that students could exhibit through methods, projects, innovation, and studies, and was placed at the center to align with the AMIA motto: *informatics professionals leading the way*.

The final model produced by the HIAC task force defined 14 focal areas for HI: 7 describing knowledge areas, and 7 describing areas of skills. The model was presented at multiple venues in 2015 (Table 1).

Subsequent to the work of the HIAC task force, the AAC launched its work effort with an inaugural meeting among members of HIAC, AAC, and AMIA leadership on March 18, 2016. The AAC understood that the foundational domains and accompanying example statements of knowledge, skills, and attitudes had to be written in a manner that provided a common core for competency building that could apply across the subdisciplines represented by all AMIA constituents (translational bioinformatics, clinical informatics, public health informatics, consumer health informatics, and clinical research informatics) as well as within the focus of individual programs.

In the process of establishing the foundational domains, the AAC examined the output of the HIAC task force and reviewed the 2012 White Paper, the literature published on the skills and practices related to the field of health informatics, as well as the literature on the general concepts of competency and the mastery of learning. The committee incorporated scholarship written for the three domains of learning, ie, cognitive, affective, and psychomotor by Bloom, Krathwohl, Dave, and others, in its deliberations.[11–13] Embracing the Dreyfus Model of Skill Acquisition (later adapted by Patricia Benner in her seminal nursing theory on stages of clinical competence), the committee adopted a "competent/proficient level of skills acquisition at the time of graduation" to frame its discussions.[14–16]

As a standard point of reference for its work, AAC adopted the following definitions for the terms competence and competency (Table 2).

In updating curriculum standards and requirements, particularly the framework, content, and processes represented in the HIAC task force Venn diagrams, the AAC employed a deliberative process of review and revision to refine each of the HIAC domains as well as to explore additional domains that may have been needed, given the evolution of the profession since the 2012 White Paper.[18] The process for establishing the foundational domains for accreditation required completing 3 tasks: 1) identifying and naming the domains needed in the present health informatics field, 2) describing each domain clearly and succinctly, and 3) describing examples of key aspects of competencies (knowledge, skills, and attitudes) associated with each domain—capabilities to be demonstrated by a student at the time of graduation from an applied master of science in health informatics program. Following the March inaugural meeting, the members of AAC deliberated and through an iterative process, at the next meeting in April, reduced the 14 areas originally proposed by HIAC to 10 foundational domains, in concept. The committee then drafted and/or edited the domain name, wrote a description for each domain, and proposed example statements of knowledge, skills, and attitudes—the components of a competency—expected of new graduates. Seeking input during the process of deliberation,

Table 2. Definitions (KSA acronym for Knowledge, Skills, and Attitudes)

Competency – "An observable ability of a health professional, integrating multiple components such as knowledge, skills, values, and attitudes. Since competencies are observable, they can be measured and assessed to ensure their acquisition. Competencies can be assembled like building blocks to facilitate progressive development."[17]
Competence – "The array of abilities across multiple domains or aspects of performance in a certain context. Statements about competence require descriptive qualifiers to define the relevant abilities, context, and stage of training. Competence is multi-dimensional and dynamic. It changes with time, experience, and setting."[17]

committee members presented the first draft of the domains to attendees of the InSpire conference in Columbus, Ohio, in June 2016, as part of the session by CAHIIM on accreditation standards for programs.

Public comment and board approval

By September 2016, the AAC had refined the work of the HIAC taskforce and established a set of foundational domains and descriptions with accompanying examples of knowledge, skills, and attitudes necessary to succeed as health informatics professionals or health informaticians. AAC and members of AMIA Leadership prepared the document for dissemination for public comment. Table 1 summarizes the timelines for developing and vetting the AMIA foundational domains document and its insertion into the CAHIIM 2017 accreditation standards. Under the 2017 standards, new programs seeking accreditation must comply with the officially termed *AMIA 2017 Core Competencies for Health Informatics Education at the Master's Degree Level* that are part of the *2017 Standards for Accreditation of Master's Degree Programs in Health Informatics*.[19] All programs either currently accredited by CAHIIM or in the initial accreditation process must be in compliance by January 1, 2020.

AMIA 2017 CORE COMPETENCIES FOR APPLIED HEALTH INFORMATICS EDUCATION AT THE MASTER'S DEGREE LEVEL

The newly refined foundational domains with example statements of knowledge, skills, and attitudes (key components of competencies) are intended for curriculum development and accreditation quality assessment for graduate (master's level) education in applied health informatics. The application areas of health informatics, ranging from translational bioinformatics to clinical and public health informatics, span the spectrum from molecular to population levels of health and biomedicine. An in-depth discussion of each of the application areas can be found under The Science of Informatics at the AMIA website https://www.amia.org/about-amia/science-informatics

For the purposes of the foundational domains, the AAC used the following definitions:

- Clinical informatics is the application of informatics and information technology to deliver healthcare services, including medical, nursing, pharmacy, and dental informatics.
- Public health informatics is the application of informatics in areas of public health, including population health, surveillance, prevention, preparedness, and health promotion.
- Consumer health informatics is the field devoted to informatics from multiple consumer or patient views.
- Translational bioinformatics includes the development of storage, analytic, and interpretive methods to optimize the transformation of increasingly voluminous biomedical data and genomic data, into proactive, predictive, preventive, and participatory health.
- Clinical research informatics (CRI) includes the use of informatics in the discovery and management of new knowledge relating to health and disease. CRI and translational bioinformatics are the primary informatics domains supporting translational research.

The discipline of health informatics exists at the confluence of 3 major domains: Health, Information Science and Technology, and Social and Behavioral Science (represented by F1, F2, and F3 in Figure 1). Graduate students in this discipline are expected to have working knowledge of these 3 domains, as these domains define and affect the practice of health informatics. Where 2 foundational domains intermingle, each affects the other, and the graduate student is expected to demonstrate the knowledge, skills, and attitudes that exist in these co-mingled domains: Health Information Science and Technology, Human Factors and Socio-technical Systems, and Social and Behavioral Aspects of Health (F4, F5, and F6). Where all 3 domains intermingle, the graduate student is expected to demonstrate the knowledge, skills, and attitudes that exist in this most complex domain: Social, Behavioral, and Information Science and Technology Applied to Health (F7). As with all other health professions, the work of health informaticians affects the health, safety, and effectiveness of those working and being cared for within the system of health care delivery. Graduate students are also expected to demonstrate the knowledge, skills, and attitudes reflecting the domains of Professionalism, Interprofessional Collaborative Practice, and Leadership (Figure 1).

Table 3 summarizes the 10 foundational domains. Please see the Appendix for full descriptions of the domains along with their accompanying example statements of knowledge, skills, and attitudes, which can be used to develop program-specific competencies to reflect the program's focus within an AMIA Application Area.

DISCUSSION

These foundational domains and example statements of knowledge, skills, and attitudes provide a step forward in defining the core competencies for applied health informatics education and practice, reflecting the expansion of the field as it has evolved since 2012. The embedding of these domains into the accreditation standards provides a basis for curriculum development and quality assurance across a wide variety of health informatics programs by applying the competency framework to a program's specific application area of expertise.

Why change from content to competencies?

Knox and colleagues proposed in 2014 that we can no longer continue to emphasize only rote performance based on content. Rather, we should cultivate performance that demonstrates an understanding and application of principles and processes that will prepare graduates for continuous learning of new skills and techniques as their futures evolve.[20] The endpoint of all curricula—clinical informatics, public health informatics, consumer health informatics, translational bioinformatics, clinical research informatics—must

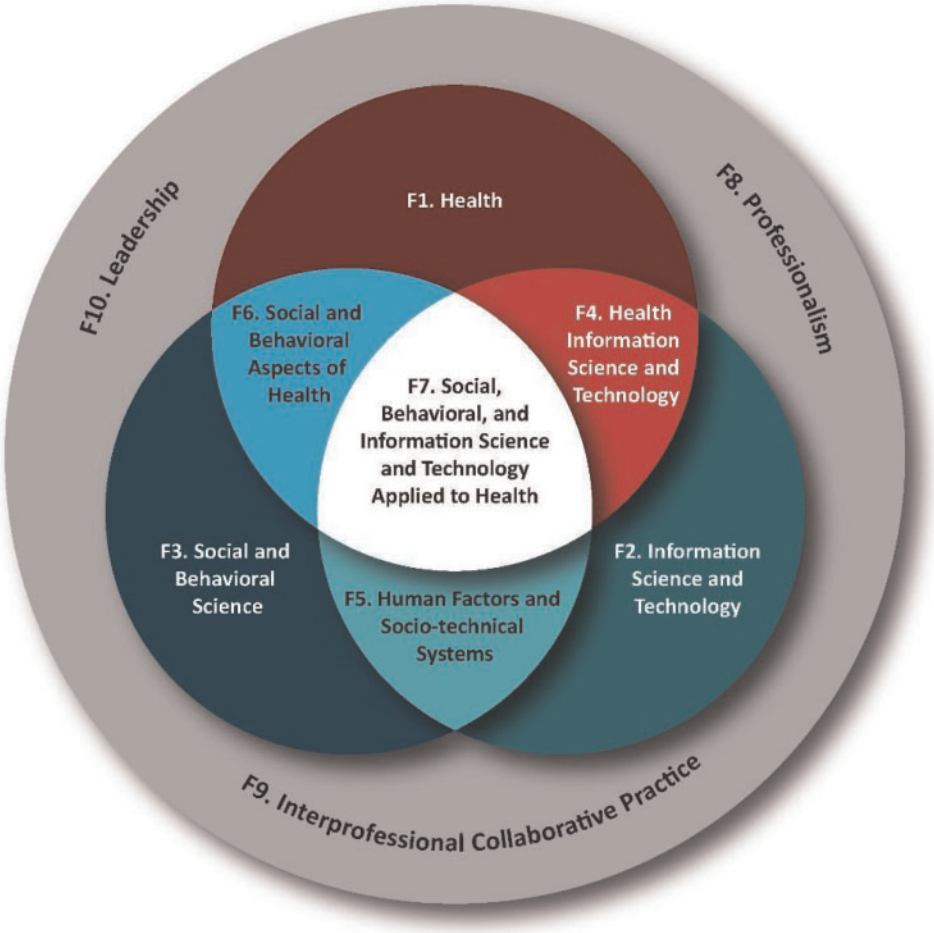

Figure 1. Foundational domains of applied health informatics. Graphic: Christina Lorenzo, MS in Biomedical Visualization, 2017, Department of Biomedical and Health Information Sciences, University of Illinois at Chicago.

integrate all 10 domains illustrated in Figure 1; however, the relative weight of any particular competency will differ depending on the program focus or purpose, and may be adjusted to reflect the job market demands.

Transforming curriculum

The AAC envisions the best way to integrate programmatic competencies reflecting the foundational domains is through *competency-driven curricula*. Health informatics education, as proposed, is more open to interdisciplinary learning and focuses more on problem solving and critical thinking than on traditional "sit and get" learning. Moving to a *competency-driven* educational approach will require an intensive educational process and multiple assessments involving all educational and professional stakeholders (Figure 2). The approach asks programs to rethink outcomes and course expectations, moving away from rote memory to the incorporation of essential knowledge, skills, and attitudes and assessed performance of defined competencies.

Where do program directors start?

The introduction of the foundational domains within a program starts with mapping the current curriculum. Program directors should start at the endpoint of their program and identify those competencies students are expected to demonstrate at graduation that align with the foundational domains. Essentially, program directors should define the program outcomes as competencies that offer a meaningful reflection of what a graduate "knows" and what he/she can "do with that knowledge." Competencies are observable and can be measured and assessed. The content as taught in the current curriculum can be reused and reorganized to address the competencies defined in the program outcomes, resulting in a more comprehensive curriculum that integrates the domains and culminates in the acquisition of the higher level, more complex competencies.

The content of each course in a curriculum should be a stepping stone to the next one, adhering to the principles of instructional scaffolding.[21] Instructional scaffolding encompasses iterative and interconnected assessment of the intended learning objectives of each course and the instructional support and didactic approaches needed to attain the intended levels of competence. Reflecting its theoretical frameworks of Activity Theory and Knowledge Integration, instructional scaffolding facilitates the development of cohesive mental models—in this case, the scientific foundations of the health informatics.[22] Ultimately, the placement and sequence of courses leading to the program outcome competencies are determined by each individual program.

How do programs assess (measure) performance?

For decades, whether formative or summative, regardless of the format or type of assessment, all health professions educational

Table 3. Foundational domain titles and short descriptions

Domain	Name	Brief Description
F1	Health	The background knowledge of the history, goals, methods, and current challenges of the major health sciences, including human biology, genomics, clinical and translational science, health-care delivery, personal health, and public health.
F2	Information Science and Technology	The background knowledge of the concepts, terminology, methods, and tools of information science and technology for managing and analyzing data, information, and knowledge.
F3	Social and Behavioral Science	The background knowledge of the effects of social, behavioral, legal, psychological, management, cognitive, and economic theories, methods, and models applicable to health informatics from multiple levels including individual, social group, and society.
F4	Health Information Science and Technology	The knowledge, skills, and attitudes to use concepts and tools for managing and analyzing biomedical and health data, information, and knowledge. Key foci include systems design and development, standards, integration, interoperability, and protection of biomedical and health information.
F5	Human Factors and Socio-technical Systems	The knowledge, skills, and attitudes to apply social behavioral theories and human factors engineering to better understand the interaction between users and information technologies within the organizational, social, and physical contexts of their lives, and apply this understanding in information system design.
F6	Social and Behavioral Aspects of Health	The knowledge, skills, and attitudes to use social determinants of health and patient-generated data to analyze problems arising from health or disease, to recognize the implications of these problems on daily activities, and to recognize and/or develop practical solutions to managing these problems.
F7	Social, Behavioral, and Information Science and Technology Applied to Health	The knowledge, skills, and attitudes to apply the diverse foundational concepts and facets in order to develop integrative approaches to the design, implementation, and evaluation of health informatics solutions.
F8	Professionalism	The conduct that reflects the aims or qualities that characterize a professional person, encompassing especially a defined body of knowledge and skills and their lifelong maintenance as well as adherence to an ethical code.
F9	Interprofessional Collaborative Practice	Behavior that reflects the foundations of values/ethics, roles/responsibilities, interprofessional communication practices, and interprofessional teamwork for team-based practice.
F10	Leadership	Behavior that demonstrates the following characteristics: credibility, honesty, competence, ability to inspire, and ability to formulate and communicate a vision.

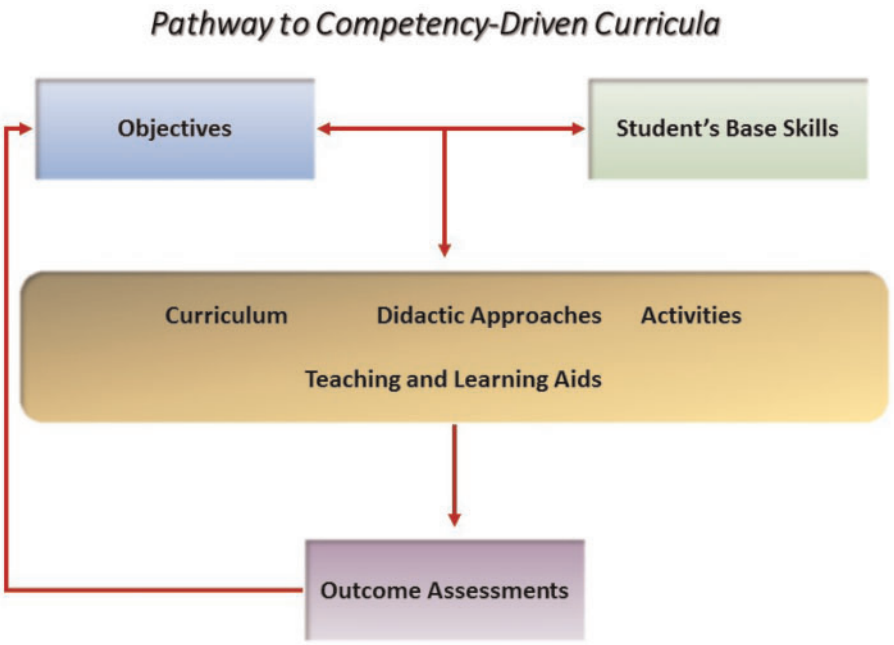

Figure 2. Path from content- to competency-driven curriculum.

programs have assessed students' attainment of knowledge. Graduate programs in health informatics, however, have far less experience in assessing attainment of technical skills and desired attitudes. Fortunately, the discipline can draw on the experiences of other health professions that have sought to build conceptual frameworks for such assessment. Conceptual frameworks for assessment of competence, such as the work of Miller and Cruess et al. in medical education, and the work of Lenburg for nursing competence, among others, can inform the assessment efforts of the discipline as it moves to a new paradigm of graduate education.[23–29]

CONCLUSION

Ultimately, the value of the competencies that programs develop will be demonstrated as graduates of health informatics programs gain employment in this field. They may become teachers or practitioners in any number of industries, based upon their and their employers' ability to articulate and apply these skills. AMIA has surveyed and analyzed industries' view of health informatics, and fosters strong relationships with public and private employers. As a past Chair of the AMIA Board of Directors stated, "I hope the move will lend some clarity to employers who seek skills, competencies, and talent that informatics graduates possess, in the nation's effort to proliferate clinical information systems using informatics tools and techniques."

Building standards across programs and the change from content-driven to competency-driven curricula is an evolutionary process. The definition of core competence is part of any accreditation standard; accreditation is one step in the journey toward professionalism of a discipline. Professional societies and their contribution to professional education (as opposed to formal graduate education) is an essential component of a profession.[30] This document will be periodically updated, as part of the responsibility of the AMIA Accreditation Committee, through continued study, education, and surveys of market trends. The active participation of AMIA within CAHIIM provides a pathway for the member programs of AMIA to speak in a more unified voice, while respecting the unique differences and diversity that make informatics such a dynamic field.

Finally, the 10 foundational domains emerged from the comprehensive review of the field in the 2012 article authored by Kulikowski and colleagues.[1] These domains define the field. Competencies are created and anchored to the level of skills acquisition appropriate for the population under consideration. Competencies can be adapted for different stages of education, including that of the baccalaureate or, potentially, doctoral program, by modifying the level of knowledge, skills, and attitudes to be expected at the time of graduation of the baccalaureate (or doctoral) student; other competencies may be required for those stages. Over time, through the iterative process of building competency-driven curricula, through national conversations at the AMIA Academic Forum and its annual Informatics Educators Forum, and through the work of the AMIA Education Committee and its subcommittee, the AMIA Accreditation Committee, insight on the foundational domains and the knowledge, skills, and attitudes required of informaticians will grow. This has been the path to the professionalization of every other health profession and will be the path taken for those in the discipline of health informatics.

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APPENDIX

AMIA 2017 core competencies for applied health informatics education at the master's degree level

INTRODUCTION

Competencies describe what a student will be able to do at a point in time. For the purpose of this document, the point in time is set at graduation from an applied master of science in health informatics program. A given competency is built upon an integrated set of knowledge, skills, and attitudes needed to perform an activity. For each of the 10 foundational domains presented here, every program must develop competency statements that reflect the individual AMIA Application Area that is the focus of the program. For each domain described below, examples are provided of knowledge, skills, and attitudes that could be reflected in competencies for those domains.

As an example, in looking at Foundational Domain F9, Interprofessional Collaborative Practice, a competency reflecting that domain from a program focusing on preparing students for an applied clinical informatics role might be "Collaborate with clinicians and administrative and technical personnel to implement a communication plan for a new EHR system." A competency for a program in translational bioinformatics from the same domain might be "Participate with clinical researchers on a team science project." Both of these competencies reflect the integration of a knowledge component that includes the knowledge about different professions, stakeholders, and team dynamics; a skill component related to relationship-building and interprofessional communication; and an attitude component related to mutual respect and shared values. The example statements of knowledge, skills, and attitudes listed within each of the domains below can be used to develop the program-specific competencies that reflect an individual program's focus within an AMIA Application Area. Programs may also define competencies within a given foundational domain that are an integration of other knowledge, skills, and attitudes that are not listed here.

As a final note, the discipline of health informatics exists at the confluence of 3 major domains: Health, Information Science and Technology, and Social and Behavioral Science (represented by F1, F2, and F3), which define and affect the practice of health informatics. During its deliberations, members of the AAC concluded that graduate students in this discipline should have working knowledge of these 3 domains as they enter their graduate work. As a result, only a statement of knowledge was developed for each of these 3 major domains.

F1. HEALTH

Health refers to the biomedical and health sciences underlying AMIA's 5 major informatics areas: translational bioinformatics, clinical research informatics, clinical informatics, consumer health informatics, and public health informatics. The biomedical and health sciences aim to understand and improve human health. To identify and develop solutions to biomedical informatics problems, students must understand the history, goals, methods (including data and information used and produced), and current challenges of the major health sciences, including human biology, genomics, clinical and translational science, healthcare delivery, personal health, and public health.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Describe the history, goals, methods (including data and information used and produced), and current challenges of the major health science fields. These include biology, genomics, clinical and translational science, healthcare delivery, personal health, and public health.

F2. INFORMATION SCIENCE AND TECHNOLOGY

Information Science and Technology refers to the key concepts, methods, and tools for creating, acquiring, storing, representing, accessing, merging, organizing, processing, transferring, analyzing, reporting, and visualizing data, information, and knowledge. It also includes the methods and tools for protection of the data, information, and knowledge from unauthorized access. Included are understanding how information is used and the ability to assess the information needs of users. Familiarity is required with basic computer science terminology and concepts, including terms and concepts related to information systems and computer programming,

information retrieval, ontologies, business intelligence, analytics, and user interface design.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Identify the applicable information science and technology concepts, methods, and tools, which may be dependent upon the application area of the training program, to solve health informatics problems. These include the concepts, methods, and tools related to managing data, information, and knowledge, the basic information and computer science terms and concepts, the principles of information security, as well as the methods of assessing users' information needs.

F3. SOCIAL AND BEHAVIORAL SCIENCE

Social and Behavioral Science refers to basic social, behavioral, psychological, and management theories, methods, and models as well as the legal and regulatory frameworks that seek to describe human actions and interactions as well as human behavior in society. It includes concepts from fields such as sociology, economics, anthropology, political science, law, psychology, and management and cognitive sciences. It is concerned with the application of social, behavioral, psychological, and management theories, methods, and models to the design, implementation, and evaluation of health information behaviors at the levels of individual, social group, organizations, and society, which are influenced by laws and regulations. The purpose is to contribute to decreasing health-damaging behaviors and improving health-promoting behaviors and psychosocial well-being through health informatics perspectives.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Identify the effects of social, behavioral, legal, psychological, management, cognitive, and economic theories, methods, and models applicable to health informatics from multiple levels, including individual, social group, and society.

F4. HEALTH INFORMATION SCIENCE AND TECHNOLOGY

Health Information Science and Technology refers to the array of health information science and technology methods, tools, and standards for collecting, organizing, representing, sharing, integrating, using, governing, and learning from biomedical and health data, information, and knowledge across the entire spectrum of informatics domains. Systems design and development addresses standards, integration, interoperability, and protection of information. These competencies also address computational thinking, which includes problem solving, systems design, and understanding human behavior, as associated with computer science.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Identify possible biomedical and health information science and technology methods and tools for solving a specific biomedical and health information problem. Core health information technology tools may be dependent upon the application area of the training program.

Skills

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Design a solution to a biomedical or health information problem by applying computational and systems thinking, information science, and technology.

Attitudes/abilities

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Demonstrate consideration of the advantages and limitations of using information science and technology to solve biomedical and health information problems as well as the needs of the different stakeholders and context.

F5. HUMAN FACTORS AND SOCIO-TECHNICAL SYSTEMS

Human Factors and Socio-technical Systems refers to the interactions between human behaviors (physical, social, cognitive, and psychological) and information technologies. People and organizations are the ultimate users of health information and technologies. This domain draws on the social, behavioral, cognitive, economic, human factors engineering, and management and systems sciences in considering the needs, workflows, and practices of individuals and organizations in the context of information systems and technology.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Draw on socio-technical knowledge regarding the social behavioral sciences and human factors engineering to apply to the design and implementation of information systems and technology.

Skills

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Apply social behavioral theories and human factors engineering to the design and evaluation of information systems and technology.

Attitudes/abilities

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Demonstrate consideration and respect for the role of users in the design and application of information systems and technology.

F6. SOCIAL AND BEHAVIORAL ASPECTS OF HEALTH

Social and Behavioral Aspects of Health refers to action(s) taken by an individual, groups of individuals, or an organization to manage the health of an individual or population. It entails social determinants and patient-generated data, analyses of problems arising from health or disease, the implications of these problems on daily activities, and the practical solutions to managing these problems. Patient behavior (that may be affected by genotypes and phenotypes), health literacy, informed decision making, patient engagement, and patient activation are examples of issues in this domain. Other common topics in this domain, depending on the program focus, may include health-behavioral paradigms, such as health and healthcare self-management, substance abuse, utilization of healthcare services, characteristics of nutrition, exercise/physical activity habits, organizational network analyses, precision medicine and individualized care, etc.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Identify theories or models that explain and modify patient or population behaviors related to health and health outcome.

Skills

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Apply models, which may be dependent upon the application area of the training program, to address social and behavioral problems related to health of individuals, populations, and organizations.

Attitudes/abilities

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Acknowledge the importance of social and behavioral aspects of health and their contribution to the health of individuals and populations.

F7. SOCIAL, BEHAVIORAL, AND INFORMATION SCIENCE AND TECHNOLOGY APPLIED TO HEALTH

Social, Behavioral, and Information Science and Technology Applied to Health refers to the integration of social, business, human factors, behavioral, and information sciences and technology on the design, implementation, and evaluation of health informatics solutions. The application of health technologies and clinical and/or business processes can impact individual and community health outcomes at numerous levels from molecular and biological systems, to healthcare and organizational protocols, to social systems and public health.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Identify the theories, models, and tools from social, business, human factors, behavioral, and information sciences and technologies for designing, implementing, and evaluating health informatics solutions. Theories, models, and tools may be dependent upon the application area of the training program.

Skills

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Integrate and apply the theories, models, and tools from social, business, human factors, behavioral, and information sciences and technologies to design, implement, and evaluate health informatics solutions. Theories, models, and tools may be dependent upon the application area of the training program.

Attitudes/abilities

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Demonstrate an awareness of the interrelatedness of social, business, human factors, behavioral, and information sciences and technology in the design, implementation, and evaluation of health informatics solutions.

F8. PROFESSIONALISM

Professionalism refers to the level of excellence or competence that is expected of a health informatics professional and includes such concepts as the maintenance and utilization of knowledge and technical skills, which may be dependent upon the application area of the training program; commitment to professional ethical principles including those in AMIA's Code of Ethics; and maintenance of the highest standards of excellence in the field including professional development. In health informatics, there is a particular emphasis on preserving the confidentiality, privacy, and security of patient and other health data and information, and balancing it with appropriate stakeholder access.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Define and discuss ethical principles and the informaticians' responsibilities to the profession, their employers, and ultimately to the stakeholders of the informatics solutions they create and maintain.

Skills

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Demonstrate professional practices that incorporate ethical principles and values of the discipline.

Attitudes/abilities

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Demonstrate awareness of the value of information literacy and lifelong learning, maintenance of skills, and professional excellence.

F9. INTERPROFESSIONAL COLLABORATIVE PRACTICE

Interprofessional Collaborative Practice (ICP) refers to the shared, coordinated work among peers from different professions in order to achieve a common goal or mission. The work may range from local projects to those on a national and international scale, and should be performed in an ethical manner that involves honesty, integrity, trust, and respect. Part of this domain is teamwork and team science, which involves drawing on individual team members' strengths and expertise and assigning designated roles and methods to achieve the goals and mission. ICP requires effective communication skills. In summary, the domain requires mastery of values/ethics, roles/responsibilities, interprofessional communication, and team/teamwork.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . ..

Define and discuss the scope of practice and roles of different health professionals and stakeholders including patients, as well as the principles of team science and team dynamics to solve complex health and health information problems.

Skills

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Apply relationship-building skills and the principles of interprofessional communication in a responsive and responsible manner that supports a team approach to solve complex health and health information problems.

Attitude/abilities

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Recognize the importance of mutual respect and shared values, as well as one's own role, the role of other professions and stakeholders including patients, and the role of teamwork and team science to solve complex health and health information problems.

F10. LEADERSHIP

Leadership refers to the interactive process for which the output is vision, guidance, and direction. Essentials of leadership include vision, communication skills, stewardship, acting as a change agent, and the developing and renewing of followers and future leaders. Leaders must envision goals, set priorities, manage change, make decisions, communicate, serve as a symbol of one who is willing to take risks and has credible expertise, and guide others by motivating other leaders as well as those who will follow. The concept of followership refers to a role held by certain individuals in an organization, team, or group. Specifically, it is the capacity of an individual to actively follow a leader. For leaders to be successful at leadership, they must possess the following characteristics: credibility, honesty, competence, ability to inspire, and the ability to formulate and communicate a vision.

Knowledge

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Articulate the methods, concepts, tools, and characteristics of leading and leadership.

Skills

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Employ leadership and followership methods, concepts, and tools to motivate others toward accomplishing a health informatics vision.

Attitude/abilities

At the time of graduation from an applied master of science in health informatics program, the graduate student should be able to. . . .

Demonstrate leadership behaviors for achieving a vision for health informatics solutions.

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The Chief Clinical Informatics Officer (CCIO)

Joseph Kannry, MD, *Chair, AMIA Task Force on CCIO Knowledge, Education, and Skillset Requirements*
Doug Fridsma, MD, PhD, FACP, FACMI, *President and CEO, AMIA*

AMIA has been at the forefront of advancing scientific research and education in informatics as well as public policy around issues related to clinical informatics. AMIA's multidisciplinary, interprofessional membership and strategy reflect this – we have seen a rise in the number of submissions to the AMIA Annual Symposium related to the applied areas of informatics, and more emphasis in our clinical research informatics community on applied aspects of clinical research.

An important trend to follow is the professionalization of the informatics field. The rise of accreditation in training programs, the growth of the clinical informatics subspecialty board diplomates (1000+), and the future development of the advanced health informatics certification has, and will, lead to an increase in the number of informatics professionals in leadership roles within their healthcare organizations.

This professionalization is in part being driven by the measurable growth in investments in the applied use of information technology in healthcare with emphasis on the deployment and utilization of electronic health records. We have seen a rapid increase in the adoption of electronic health records and other health information technology, and with it, the rise in leadership positions that recognize the importance of informatics to use technology in a strategic way.

The AMIA Board of Directors supported paper **The Chief Clinical Informatics Officer (CCIO): AMIA Task Force Report on CCIO Knowledge, Education, and Skillset Requirements**[1] published in the *Applied Clinical Informatics Journal* is a reflection of AMIA's support for and advancement of the professionalism of informatics in operational roles in healthcare organizations. At its core the paper reinforces the important linkage between the previously developed and evolving standards for clinical informatics knowledge and education and the operational role of the CCIO. It is not surprising that AMIA would support such a linkage since AMIA and AMIA members fostered and developed such standards.

The term CCIO is used to describe the person in charge of "Clinical Informatics." The term encompasses the more commonly used Chief Medical Informatics Officer and Chief Nursing Informatics Officer as well as the rarely used Chief Pharmacy Informatics Officer and Chief Dental Informatics Officer. While CCIOs may originate from clinical disciplines including dentists, pharmacists, nurses, and physicians, historically and currently non-clinicians have very successfully executed this role.[1]

During this time, where the need for clinical informatics was never greater or more in demand, the AMIA board, established a task force to understand better what the knowledge, education, and operational skillset are needed for CCIOs. Reflecting AMIA's belief that informatics crosses healthcare professional boundaries and that informaticians have more in common than they do differences, the task force composition was interdisciplinary and comprised of physicians, nurses, a pharmacist, and a dentist. The report not only noted what was common across these different areas, but also provides a description of what is different between these different groups within the CCIO framework, and the level of maturity within these diverse domains.

The role of the CCIO currently is diverse at present, but the growing body of Chief Clinical Informaticians "completing clearly defined and specified Clinical Informatics education and training" including board certification and/or other education and training equivalent in rigor to certification. Consequently, the efforts to develop an advance health informatics certificate are beginning to see a convergence in the recognized and required skill set and expertise. In fact, the results of the most recent advanced health informatics certification report suggests that keeping a core of executive and advanced skills across these different professional groups is to the benefit of all.

Clearly, the task force white paper is the first step for the field of informatics to continue to define and refine the required education and skillset for all CCIO positions. As informatics knowledge and education continue to evolve and grow there will be a need to revisit CCIO education and CCIO skillsets. Formally educated and trained CCIOs will provide a competitive advantage for their respective enterprise by fully utilizing the power of informatics science. These CCIOs will enable the United States to transform the way in which health care is delivered, how it is paid for, and give the United States the healthcare system it needs and deserves.

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The purpose of the Messages from AMIA section is to provide a forum for AMIA to inform and involve its current and potential members about the goals and the directions of the association. These messages, which reflect the directions and opinions of AMIA leaders only, are intended to inspire members and readers to connect with the association on strategic objectives and activities. See also http://www.amia.org/presidents-page.