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A Survey of Imaging Informatics Fellowships and Their Curricula: Current State Assessment

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Abstract
In a 2016 survey of imaging informatics ("II") fellowship graduates, the surveyed fellowship graduates expressed the "opinion that II fellowships needed further formalization and standardization" Liao et al. (J Digit Imaging, 2016). This, coupled with the fact that the original published "standardized" curriculum is about 15 years out of date in our rapidly changing systems, suggests an opportunity for curriculum improvement. Before agreeing on improved structural and content suggestions for fellowships, we completed a current-state assessment of how each fellowship organizes its education and what requirements each have for fellowship completion. In this work, we aimed to collect existing information about imaging informatics fellowship curricula by contacting institutions across the country. A survey was completed by phone with the fellowship directors of existing imaging informatics fellowships across the country. Additionally, we collected existing documentation that outlines the curricula currently in use at institutions. We reviewed both the interview responses and documentation to assess overlapping trends and institutional differences in curriculum structure and content. All fellowships had suggested reading lists, didactic lectures, and a required project for each fellow. There were required practicum activities or teaching experience each in two fellowships, and one fellowship had a mandatory certification requirement for graduation. Curriculum topics in Technical Informatics or Business and Management were covered by a majority of institutions, while Quality and Safety and Research topics had inconsistent coverage across fellowships. Our plan is to reengage II fellowship directors to develop a core curriculum, which is part of the Society of Imaging Informatics in Medicine strategic plan.

Keywords Fellowship · Education · Academics · Curriculum · Imaging informatics

Hypothesis

Each imaging informatics fellowship currently has a unique curriculum, with significant overlapping components that could be utilized to develop a published common core curriculum for the future.

Background

In the early 2000s, a suggested "standardized" curriculum for an imaging informatics fellowship was published online by the Society for Computer Applications in Radiology (SCAR) and outlined in a 2004 article in the Journal of

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Digital Imaging [1]. At that time, the standardized curriculum had components which covered IT, clinical informatics, PACS administration, and academics. Since that time, there have been significant advances in medical imaging technology and data sciences such as the development of new interoperability standards, new consumer technologies, and advances in machine learning and artificial intelligence.

There is a wealth of suggested educational resources and program structures for biomedical and clinical informatics available when conducting a literature review, but imaging informatics updates have been limited to a few proposals for residency program or medical school integration [2, 3]. In the last 15 or so years, no further modifications to the medical imaging informatics fellowship curriculum have been published.

In a more recent 2016 survey of imaging informatics fellowship graduates, 27 surveyed fellowship graduates expressed the "opinion that II fellowships needed further formalization and standardization" [4]. Medical residents and students have expressed an increasing interest in imaging informatics as "Machine Learning" and "AI" come to the forefront of the news media, prompting exploration of information technology by trainees who previously had not heard of the field. Savvy physicians are attending programming courses and deep learning lectures, leading to standing-room-only events at national conferences. This increased interest will likely generate a new wave of imaging informatics professionals, which will require a robust educational system to accommodate the learners and provide consistent, high-quality education. At this point in time, imaging informatics fellowships are associated with ACGME-approved radiology programs but are not ACGME-approved themselves. This has allowed the fellowship programs a great deal of flexibility in all aspects of the curriculum, admissions, and graduation requirements but may also have hindered coordination of educational structure and topics across fellowships.

This, coupled with the fact that the original published "standardized" curriculum [1] is about 15 years old and now out of date in our rapidly changing systems and data, suggests an opportunity for curriculum improvement.

Before determining improved structural and content suggestions for fellowships, we need to complete a current-state assessment of how each fellowship organizes their education and what requirements they have for fellowship completion. In this work, we aimed to collect existing information about imaging informatics fellowship curricula by contacting institutions across the country.

The results of this research may help guide the development of a universal imaging informatics fellowship curriculum, which is a current strategic goal of the Society of Imaging Informatics in Medicine (SIIM). Development of an updated universal curriculum would require baseline knowledge of graduation requirements for fellowships across the country, in addition to coordination of fellowship program leadership.

Methods

To assess the current-state curricula guidelines for fellowships, we directly contacted the fellowship directors of existing fellowships listed on the SIIM website [5]. Initially, the research team completed a preliminary assessment of the fellowship information available publicly online for each fellowship, noting any curriculum details that were available. We contacted eight programs in total via email and were able to arrange interviews with six program directors. The surveyed fellowships include programs which have graduated at least one fellow and focused exclusively on imaging informatics, rather than biomedical or clinical informatics. We administered a survey over the phone. A recording of each survey was transcribed for subsequent analysis. The survey included a mixture of binary yes/no and open-ended questions. All fellowship directors were asked the same survey questions, with an option of providing any additional commentary at the end of the interview as they saw fit.

The first part of the survey included demographic data, in the form of the following questions:

- Where is your fellowship located?
- When was it established?
- How long is the fellowship program?
- How many faculties are involved in your fellowship in total? How many are core or adjunct faculty?
- How many graduates have you had? Have they all been MD fellows?
- Is the informatics fellowship required in conjunction with a clinical fellowship?
- Is there a published curriculum you can share? (If yes, where is it published)
- What other fellowships are you aware of?

If no curriculum documentation was publicly available, or provided for reference, the following questions were asked to identify the curriculum topics that each fellowship prioritized:

- What are some of the things you would expect your fellows to know at the end of the fellowship?
- What are some of the learning activities?
- Is it the same process for every fellow?
- Are there electives?
- Is it based on their interests?

The second part of the survey outlined the curriculum structure details that fellowships used by asking the following questions:

- What are the requirements to graduate from the fellowship program?
- What certifications are required?

- What is the structure of your fellowship?
- How does this informatics structure coordinate with a clinical fellowship?
- Are there required readings or tests?
- What are the time commitments for fellows?
- How does funding for the fellowship work?
- What is the application process like?

Finally, we collected any documentation published internally or externally that was provided by the fellowship director to outline the curricula currently in use at that institution for the imaging informatics fellowship. Once all surveys were completed, we reviewed the interview transcripts and curriculum documentation to identify which curriculum topics were covered for each institution's fellowship. The topics listed could be organized into overarching categories including technical informatics, business and management, quality and safety, and research. The final curriculum topic table (Table 1) after transcript analysis also included a tally of the number of institutions that included that respective topic in their fellowship curriculum.

Results

Eight fellowship directors in total were contacted for the survey study, and six responded and completed an interview with the research team. Of the fellowships included in the study, all had fellowship graduates who had completed the program. The institutions were located along the East Coast and in the Midwest.

Fellowship Admission and Structure

All fellowships were established with their first graduates after the year 2000, and each fellowship director surveyed during this research period managed a fellowship that could be completed in 1 year and built into the clinical time of the fellows, with the exception of one program, which stated participants may take over a year to complete the hour requirements. The number of graduated fellows varied widely, between 1 and 50 MD (or DO) graduates in total, and programs could vary between accepting one formal fellow each year to allowing a classroom full of participants. The programs vary widely in the number of graduates on a yearly basis, with one program graduating about 180 graduates of all degree types over 7 years, while another graduated 20 people over the course of 18 years. All fellowship directors could describe a formal curriculum with graduation requirements and lecture topics. Only two programs had a formal outline of fellowship structure, requirements, and teaching points published publicly online, but all the remaining fellowships at least had guidelines

Table 1 Count of Imaging Informatics Fellowships (of 6) addressing Educational Topics

	Curriculum Topics (*Examples*)	#
Business and Management	Business Analytics	4
	Communications Communication Strategy, Tools	4
	Education	1
	Finance Informatics Funding, Purchasing, Procurement, Revenue Cycle	3
	Meaningful Use	3
	PMO (Program Management Office) Requirements Gathering, Usability Analysis, Workflow Modeling/Optimization, Change Mgmt	5
	Business Management Skills Negotiation, Leadership, HR, Organizational Design	5
	System Implementation Implementation and upgrades of clinical systems, System evaluations	5
Technical Informatics	Data Science Information visualization, ETL, Database Design	5
	Department Infrastructure Image Acquisition Process, Critical Results, Tech Feedback, Protocoling, Peer Review	2
	Enterprise Imaging	5
	Infrastructure (Computers, Networking) Storage area networks, server architecture, high-availability design, CMM	5
	Other 3D Printing, Ergonomics, Human Factors Engineering, Social Media, Specialty PACs	4
	PACs/RIS/Reporting	6
	Programming/Development/Software Web Services, Machine Learning, Scripting, PHP, System Design, NLP, Image Segmentation	6
	Security	2
	Standards HL7, DICOM, IHE, ITIL, System Interoperability	6
	Study Management	1
Quality and Safety	Compliance/Regulatory	3
	Decision Support	4
	HIPAA	3
	Patient Safety	2
	Quality	3
	Radiation Dose	2
Research	Evaluation Models/Methods	2
	Honest broker architectures	2
	IRB implications on informatics	4
	Quasi-experimental Study Design	4
	Surveying methods	3

outlined and available internally that were shared with the research team.

One third of surveyed programs have turned down fellowship applicants in the past, but directors explained that in each instance, fellowship applicants discussed their personal goals with fellowship directors and could be directed to other opportunities if they did not have a good fit with the program goals. Non-MD applicants are accepted into half of the six surveyed programs, which could include PhDs, nurses, information technology staff members, or medical physics residents. Of these three programs, two also allow applicants to participate in lectures, projects, and fellowship activities without fully completing the fellowship graduation requirements.

Graduation Requirements

All fellowship curricula required attendance at didactic sessions and completion of an individual project to successfully graduate (Fig. 1).

The didactic lectures required attendance ranging from 75 to 100% from fellows depending on the institution, and there were two programs which allowed fellows explicit opportunities to teach either by leading a journal club or a medical resident lecture.

Publication was expected of their fellows by two thirds of the surveyed programs; however, the remaining two stated that while publication was not a direct requirement, it was "highly encouraged," either at an institutional research event or a national conference. For most programs requiring research publication, a meeting abstract submission was considered the minimum.

An individual project component was a requirement in all fellowships surveyed, with the option for fellows to either select their own project topic or to work with faculty to select a project from a list of options suggested by the department.

Certification options for imaging informatics professions include the Certified Imaging Informatics Professional (CIIP) by the American Board of Imaging Informatics, the Certified Professional in Health Informatics by the American Health Information Management Association, and subspecialty board examination in clinical informatics through the American Board of Preventative Medicine. One program required their fellowship graduates to complete a certification at the end of their fellowship, and two additional programs strongly encouraged the CIIP certification in particular.

There were no programs which had "required" readings or additional tests of knowledge, but every fellowship director provided a list of "suggested" reading material from multiple sources. Readings could include journal articles, books, the "Practical Imaging Informatics" [6] textbook, readings provided by the National Imaging Informatics Curriculum (NIIC) [7] for radiology residents, or presentation files from subject matter experts.

The two fellowship programs which included practicum (e.g., shadowing an established informatics professional for a period of time) requirements in their curriculum were also the two fellowships who have non-MD fellows in their programs.

Curriculum Topics

The curriculum topics listed by fellowship directors either during the phone interview or in their shared curriculum documentation could be categorized into the following groups: business and management, technical informatics, quality and safety, and research (Table 1). The business and management

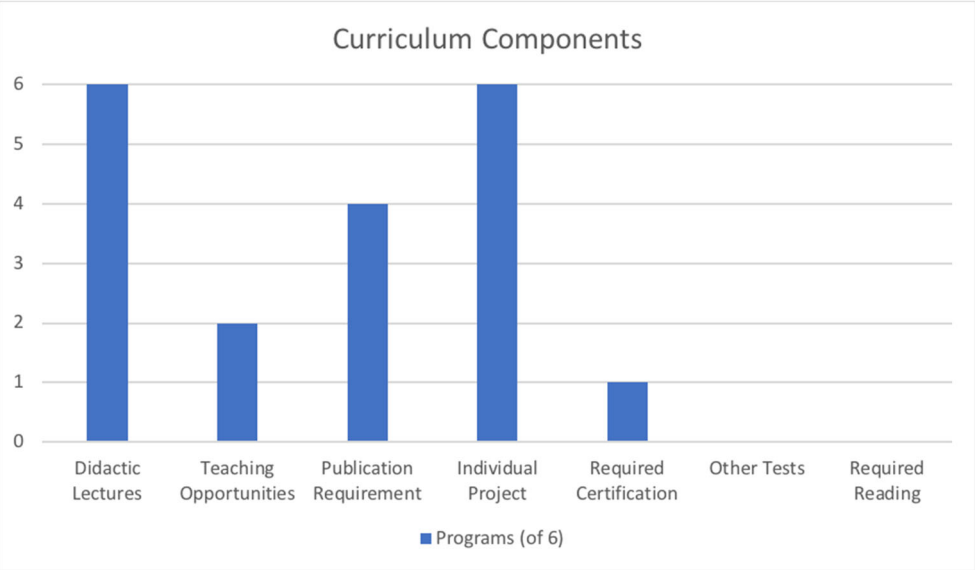

Fig. 1 Components of imaging informatics fellowship structure

topics had 62.5% (5 of 8) included in at least four of the program curriculums, and the technical informatics had 70% (7 of 10) included in at least four program curriculums. The quality and safety group and the research group had less than half of their total topics covered consistently by a majority of the surveyed programs.

Discussion

Since the initiation of the first fellowships, the need for trained imaging informatics professionals has grown over time. Technological advances have included the continued adoption of new medical imaging software, hardware, security standards, and quality improvement opportunities. Few remaining healthcare systems do not use a PACS, and medical imaging technology continues to evolve at a rapid rate. A corresponding increase in informatics interest is taking place among residents and medical students, supported by the National Imaging Informatics course and the SIIM residents, fellows, and doctoral students section (introduced for the first time at the 2018 SIIM Annual Meeting). The combination of a growing professional requirement and interested trainees necessitates the establishment of an educational structure capable of providing consistent and up-to-date training.

Imaging informatics education currently exists in several formats, depending on the learner's goals. The Annual SIIM boot camp is a one-day long event that prepares its attendees for the CIIP exam or provides a refresher on informatics to allow attendees to identify their strengths and weaknesses. This course is designed to provide a broad but intense overview to learners who are already versed in the imaging informatics field and who want to continue with deeper learning. The NIIC, which is sponsored by the RSNA and SIIM, is a week-long course for residents. Institutions across the country dedicate time for their senior radiology residents to listen to recorded lectures, participate in live, interactive sessions, and complete offline reading and homework assignments, in order to gain a fundamental understanding of imaging informatics and how the field might impact their career. The NIIC course serves as an introduction to imaging informatics for all residents and provides a basic understanding to residents who may not intend to pursue advanced training or a career in imaging informatics.

Both the NIIC course and the SIIM boot camp provide a coordinated curriculum for participants, with standardized topics, tasks, and learning expectations that allow for performance tracking and targeted learning opportunities. The imaging informatics fellowship allows for the most extensive informatics education of all, preparing informatics professionals for a career of interprofessional communication and hands-on project management or system implementation while continuing their professional education in an ever-changing environment of technology and data science. Our research highlights the areas of consistency in technical informatics and business management that could easily be built into a core curriculum, with individual projects, weekly lectures, and a reliable bank of reading sources for fellows. The project also identified points for discussion, including current discrepancies in the aspects of research, quality, and safety that are expected educational topics for fellows. The core curriculum will also need to address whether practicum activities, teaching, or certification will continue to be a requirement for fellows going forward or if those items can be unique to each institution.

Our study is limited by a small sample size of formal, established, imaging informatics fellowships. However, the planned coordination of the fellowship directors in the development of a common core curriculum should allow for further discussion of educational variations across fellowships and can include leadership from institutions that hope to initialize their own programs.

Finally, there were a number of questions raised with the research team during the interviews with program directors. For programs that currently allow non-MD participants or participants who do not intent to complete the program but would rather attend for their own interest, how does a formal curriculum work with those wishing to "audit" the fellowship course? Will applicants with a technical versus a non-technical background be able to benefit from a standardized fellowship? How would a standardized core curriculum impact the funding or expected time commitments of fellows who are concurrently completing clinical requirements? All of these points will require further evaluation and discussion among the fellowship directors themselves, as they work in tandem to create an Imaging Informatics Core Curriculum. This core curriculum is already part of the current SIIM strategic plan.

Conclusion

In summary, we were able to complete a current-state analysis of the graduation requirements for II fellowships. All surveyed fellowships had required didactic lectures, a project, and readings. A minority of fellowships also had additional requirements to graduate, including teaching experiences, certifications or "practicum" activities. While each fellowship had a unique mixture of curriculum teaching points, the majority of fellowships were in agreement on education of technical informatics and business and management topics. Curriculum topics involving quality and safety and research were less consistent across institutions. Now that a current-state analysis has been completed, we plan to reengage imaging informatics fellowship directors to develop a core curriculum based on the significant overlap of educational topics and discussion of subject matter discrepancies. This initiative is part of the

current SIIM strategic plan and will improve consistency of fellowship education and scope. By developing a common standard for imaging informatics fellowships across the country, we hope to allow for improved educational consistency and scope across the fellowships.

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