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Original Article

# A core curriculum for clinical fellowship training in pathology informatics

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## Abstract

**Background:** In 2007, our healthcare system established a clinical fellowship program in Pathology Informatics. In 2010 a core didactic course was implemented to supplement the fellowship research and operational rotations. In 2011, the course was enhanced by a formal, structured core curriculum and reading list. We present and discuss our rationale and development process for the Core Curriculum and the role it plays in our Pathology Informatics Fellowship Training Program. **Materials and Methods:** The Core Curriculum for Pathology Informatics was developed, and is maintained, through the combined efforts of our Pathology Informatics Fellows and Faculty. The curriculum was created with a three-tiered structure, consisting of divisions, topics, and subtopics. Primary (required) and suggested readings were selected for each subtopic in the curriculum and incorporated into a curated reading list, which is reviewed and maintained on a regular basis. **Results:** Our Core Curriculum is composed of four major divisions, 22 topics, and 92 subtopics that cover the wide breadth of Pathology Informatics. The four major divisions include: (1) Information Fundamentals, (2) Information Systems, (3) Workflow and Process, and (4) Governance and Management. A detailed, comprehensive reading list for the curriculum is presented in the Appendix to the manuscript and contains 570 total readings (current as of March 2012). **Discussion:** The adoption of a formal, core curriculum in a Pathology Informatics fellowship has significant impacts on both fellowship training and the general field of Pathology Informatics itself. For a fellowship, a core curriculum defines a basic, common scope of knowledge that the fellowship expects all of its graduates will know, while at the same time enhancing and broadening the traditional fellowship experience of research and operational rotations. For the field of Pathology Informatics itself, a core curriculum defines to the outside world, including departments, companies, and health systems considering hiring a pathology informatician, the core knowledge set expected of a person trained in the field and, more fundamentally, it helps to define the scope of the field within Pathology and healthcare in general.

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## BACKGROUND

### Pathology Informatics and the Evolution of the Field

Pathology is a medical specialty dedicated largely to the quantitative and interpretive laboratory analysis of tissue and fluid specimens. The purpose of this analysis is to answer clinically relevant questions for specific diagnostic, public health, and research contexts through the production of accurate, reliable, and actionable information. In fact, pathology-generated data has been shown to be the most common medical information requested from Electronic Medical Records (EMRs) and forms the basis of the majority of significant medical decisions.[1,2]

Given its focus on diagnostic processes and information, it is not surprising that Pathology became an early adopter of informatics. Laboratory information systems (LIS) were among the earliest clinical information systems in hospitals,[3-5] driven by the need to organize and communicate the ever-increasing amounts of pathology-generated information. With the growth of Pathology as a specialty, the subspecialty of Pathology Informatics has expanded likewise. Clinical and Anatomic Pathology laboratories have become, and continue to be, increasingly automated and optimized through data-driven process management protocols such as Lean and Six sigma,[6-10] imaging,[11-13] automation,[14] patient safety,[15-17] decision support,[18-20] and molecular and genomic testing.[21,22] The scope of Pathology Informatics now covers the entire "total testing cycle", - including the ordering, transportation, processing, testing, resulting, interpreting, integrating, communicating, advising, and documenting of a wide range and variety of laboratory tests.[23-25]

Pathology Informatics, as a formal subspecialty, had its beginnings more than 20 years ago as pathologists began to define their roles in managing the vast amount of pathology data and clinically actionable information produced by the clinical laboratories.[26-28] Proposals for curricula for residency-based pathology informatics training were made as early as 1992[29,30] and more recently in 2003,[31] however these have only seen scattered implementation over the past decades.[32-34] In fact, less than 20% of residency programs in the United States has offered or currently offers a "dedicated rotation" in pathology informatics, and of those, the scope and quality of those rotations varies greatly.[35]

The first formal clinical fellowship in Pathology Informatics was established in 1995 at the University of Pittsburgh, and as of March 2012, the Association of Pathology Informatics (API) lists five formal fellowship programs on its website (Henry Ford Health System, Johns Hopkins Hospital, Partners Healthcare, University of Michigan, and University of Pittsburgh).[36] In aggregate, there have been less than 20 graduates of these programs to date.

### Our Pathology Informatics Clinical Fellowship Program

Our Pathology Informatics Clinical Fellowship Program, established in 2007, currently operates in two large academic hospitals and a large community hospital with a strong outreach practice. The fellowship is overseen by our healthcare system's central Educational Committee, which is responsible for all graduate medical education throughout the healthcare system. The fellowship has a formal charter, known as the "Program Description and Written Curriculum," that defines the structure and operation of the program. The charter has been approved by the fellowship program director, each participating institution's pathology department, and the Educational Committee. This acceptance of the charter (as well as the acceptance of other official fellowship documents by the Education Committee) represents the healthcare system Office of Graduate Medical Education's (GME) approval of the program.

The fellowship program has eleven primary active faculty members and several additional associate faculty members distributed across its three main sites. Eight of the primary faculty is clinical in nature and practice across a broad range of pathology subspecialties, combining their informatics skills with their subspecialty knowledge. The other three primary faculties are purely research oriented, offering research rotations and experiences for the fellows.

The fellowship can support a wide range of fellows, both in number and in informatics interests. The number of fellows who actively participate in the program varies per year, ranging from one to seven clinical and research fellows. Each fellow participates in six main educational components that make up the fellowship. - These components include operational rotations, research rotations, clinical concentrations, a core curriculum and didactic course, attendance at national meetings,

and pathology informatics based educational retreats [Table 1].

Of these components of the fellowship, the operational rotations, research rotations, and clinical concentrations are individualized to meet the interests and expected career paths of each fellow, while the remaining components are mandatory for all and form the "common core" knowledge backbone of the fellowship program. Currently fellows can chose from four different fellowship tracks in order to best customize their fellowship experience; the structure and details of the individual fellowship tracks are discussed elsewhere.[37]

Finally, additional information concerning the educational structure and operations of the fellowship program, including how each of the educational components has been implemented, how they relate to the Accreditation Council for Graduate Medical Education (ACGME) six core competencies, and how they compare to recently proposed Clinical Informatics training programs requirements, has been previously published and is beyond the scope of this manuscript.[38]

## The Core Didactic Course

Similar to other Pathology Informatics fellowship programs, our educational program was originally designed solely around operational and research rotations, with time allotted for clinical concentrations. Rotations still remain the core of the program, with fellows customizing their rotation schedule both before and during their fellowship in order to best meet their interests and to provide them with in-depth knowledge in one or two relatively specialized areas of Pathology Informatics.

Our experience began to show, however, that while rotations were very effective in providing specialized Pathology Informatics training, there was a need to provide a common, core knowledge set across the entire

**Table 1: Pathology informatics fellowship program educational structure**

| Fellowship component | Description |
|---|---|
| Customized components of the fellowship | |
| Operational rotations | Fellows work with faculty, information services (IS) teams, and leadership committees on active long-term projects in the pathology department or health system. These projects tend to involve specific areas of informatics (e.g. LIS operations, data management, workflow analysis, imaging, etc.) and are dependent upon current active projects within one of our healthcare system's hospitals. |
| Research rotations | Fellows perform informatics research in one or more of our facilities under the mentorship of our faculty. |
| Clinical concentrations | Fellows are encouraged to attend one or more traditional Pathology or Laboratory Medicine conferences in a diagnostic subspecialty of the fellow's interest, in addition to having the ability to participate in optional, elective clinical rotations. |
| Required components of the fellowship | |
| Core curriculum and didactic course | Fellows attend a required, 92-hour series of didactic sessions over a two-year cycle, led by the fellowship program director. The didactic course is guided by a formal, core curriculum that has a curated, comprehensive reading list covering the wide scope of pathology informatics (details of the core curriculum and didactic course are the central topic of this article). |
| National meetings | Attending national meetings helps fellows understand the scope, scale, and current thoughts in Pathology Informatics, in addition to giving them opportunities to meet other pathology informaticians. Fellows must attend (and ideally present at) at least one national meeting, preferably the Association of Pathology Informatics (API) sponsored Pathology Informatics meeting or the College of American Pathologists (CAP) sponsored Pathology Visions meeting. Fellows are also encouraged to attend other national pathology meetings (e.g USCAP, CAP) and international healthcare standard working groups (e.g. DICOM, HL7) if possible. |
| Retreats | Fellows attend a series of required, one or two day-long group activities taught by either local or visiting faculty that are focused on decision making, management, and governance issues relevant to the practice of operational and research Pathology Informatics. The retreats were incorporated into the fellowship in 2011 at the request of the fellows - currently retreats are open to active fellows in formal Pathology Informatics fellowship programs across the nation. The retreats teach through interactive scenarios and case studies. |

The educational structure of our Pathology Informatics Fellowship Program. The top three components (rotations and clinical concentrations) are customized to each fellow's informatics and clinical interests, while the bottom three components are mandatory for all fellows and help build a common knowledge base

scope of the field to all fellows, regardless of their specific informatics interests.

Therefore, at the specific request of the fellows, in 2010 the program implemented a classroom "core" didactic course in Pathology Informatics. The core didactic course is run by the fellowship program director, with assistance from the senior fellows, and seeks to expose all fellows to a common, broad-based knowledge set in informatics. The evolution of this course resulted in the formal curriculum and curated reading list that is the subject of this manuscript.

### The Evolution of the Core Didactic Course and the Development of the Core Curriculum

The goals of the core didactic course were three-fold: (1) to provide fellows with a common knowledge base across the breadth of Pathology Informatics that they could draw upon for their future careers, (2) to expose fellows to different aspects of Pathology Informatics not encountered in their research and operational rotations, and (3) to encourage fellows in the program to meet at least once per week to discuss their current projects and other aspects of their training.

Initially, the core didactic course consisted of weekly one-hour sessions, during which the fellows and Program Director discussed readings on a specific informatics topic. However, at that time, neither a clearly defined syllabus, nor a structured curriculum, existed for the course. Instead, course topics were selected based on perceived need by the fellows and/or Program Director, with weekly readings chosen by the Program Director. Examples of the initial topics covered during these weekly sessions included Digital Imaging and Picture Archival and Communication Systems (PACS), Bioinformatics basics, Healthcare Finance, Lean Six Sigma, Healthcare Data Messaging and Standards (HL7, DICOM, SNOMED), and Laboratory Information Systems (LIS). In addition to discussing the weekly topics, the course itself was evaluated to ensure its proper direction and fulfillment of the course goals.

During the progression of the first year of the core didactic course, however, it became clear that a disconnect existed between our primary goals (see above) and the week-to-week execution of the course. Specifically, we realized that the breadth of the field of Pathology Informatics was much larger than we had estimated, and that there was a true need for a structured, well-defined, and curated curriculum with a comprehensive reading list. To address these issues, the decision was made in spring 2011 to redesign the core didactic course and to create a comprehensive, yet dynamic, core curriculum for the fellowship program.

## MATERIALS AND METHODS

Curriculum theory and practice can take many forms, from creating a curriculum as a syllabus for transmitting a body of knowledge, as a product that attempts to achieve specific educational and behavioral goals, as a process focusing on the interaction between teachers, students, and knowledge, or as praxis, developing the curriculum through the dynamic interaction of action and reflection.[39] For our Pathology Informatics Training Program, we set out to provide an organized, structured curriculum with defined educational goals, complete with a comprehensive, yet dynamic, syllabus and curated reading list covering the breadth of Pathology Informatics. The weekly core didactic course remains a part of the curriculum and further provides both the process and praxis that we believe is integral for informatics training.

### Creating the Curriculum

Four divisions of study were chosen as the foundation for the curriculum (see Results section below for more details). Each of the divisions was then further subdivided into separate major topics with accompanying subtopics. While the senior informatics fellow and the fellowship program director created initial drafts of the curriculum, all of the informatics faculty and fellows were instrumental in reviewing, improving, extending, and finalizing the curriculum. The choice to include specific topics and subtopics in the curriculum was based on three primary criteria: (1) the importance of the topic/subtopic within both the fields of Pathology and Informatics, (2) relevance of the topic/subtopic to pathology laboratory service, systems, and workflow, including interactions with clinical services and systems, and (3) relevance to current and future clinical service, operational, and informatics trends within Pathology.

It is of considerable note that the curriculum is intentionally designed to be dynamic in nature and to include non-pathology topics. Each topic and subtopic is subject to change and the curriculum will continue to develop over time in order to account for the evolving nature of healthcare and the availability of new reading materials. The authors acknowledge that the curriculum presented here cannot cover every possible area of study within Pathology Informatics; however, we do believe that completion of the core curriculum (readings and didactic course), in conjunction with appropriate research and operational rotations, will give graduating fellows the preparation and breadth needed for future careers in Pathology Informatics.

### Selecting the Readings

After completing the structure of the curriculum, our next goal was to provide a fully curated and comprehensive reading list for the curriculum. To do this, an exhaustive literature search was performed for each

subtopic and texts from many fields were used, including pathology, clinical informatics, biomedical informatics, bioinformatics, information science, computer science, business and healthcare finance, business process management, IT governance, leadership, management, manufacturing, and design. Readings were chosen based on four main criteria: (1) appropriateness towards the topic of study, (2) accessibility (able to be easily purchased or found; out-of-print or hard-to-find books were avoided), (3) presence of self-assessment questions, and (4) publication date.

Books and selected book chapters were favored over articles for most subtopics; where a book chapter was not available, first review articles, and then original research articles, were used. Given the rapid state of change in the fields of information technology and informatics, publications within the past five years were favored; however older readings were used where appropriate. Readings available in an electronic format (e.g. PDF, epub) were preferred given our fellows' preference for e-book readers and tablet computers (e.g. Kindle, Nook, iPad, etc.). Online access to electronic materials was also preferred, especially if available through academic library or institutional access (e.g. Springer Link, www.springerlink.com, is a source for both books and articles, has all of their content available online, and may be available with institutional access). For some subtopics, a definitive book or article was not used given that hundreds or more adequate print and web-based sources were available; in these cases the sources were chosen based on fellow and faculty discretion.

Readings for each subtopic were divided into two categories, primary and suggested readings. Primary readings were chosen to provide a general introduction to a subtopic and serve as required readings for the didactic course. Primary readings consist mostly of specific textbook chapters and review articles. Suggested readings were provided as reference to allow interested fellows to go into more depth for any given subtopic or to give fellows already familiar or expert in these areas more appropriate readings for their skill level; these readings consist mostly of whole books and original research articles. Where appropriate, websites, web-based tutorials, and presentations were provided as additional sources.

### The Core Didactic Course and Assessment of the Curriculum

As stated above, the weekly core didactic course was kept as the primary delivery method for the curriculum, with the goal being to cover all subtopics in the curriculum over a two-year period. Each weekly meeting of the core didactic course followed a set format. One of the curriculum subtopics was chosen for discussion and the primary readings assigned. Weekly discussions of the readings ranged from 60 to 90 minutes in duration.

Besides discussing the content of the topic itself, during each weekly meeting the primary readings were evaluated for the following properties: (1) appropriateness/relevance of the reading to the topic, (2) quality of the reading, (3) timeliness of the reading (was it sufficiently current for the topic?), (4) length of the readings (too long, too many?), and (5) completeness of the readings (did they sufficiently cover the topic?). Readings that did not satisfy these requirements were removed from the curriculum and replacements sought. In the case where there were not sufficient readings available for a topic, informatics faculty was asked to give presentations to help fill these gaps.

## RESULTS

### Structure and Content of the Core Curriculum for Clinical Fellowship Training in Pathology Informatics

The structure and content of the core curriculum is based on our fellowship program's definition of Pathology Informatics, "The study and management of information, information systems, and processes in pathology."

There are four primary divisions of study that serve as the foundation for the curriculum: (1) Information Fundamentals, (2) Information Systems, (3) Workflow and Process, and (4) Governance and Management [Figure 1]. These four divisions emphasize areas of study that are of fundamental importance to the everyday practice of Pathology Informatics.

Each of the divisions is further subdivided into individual topics, which are themselves subdivided into subtopics. In total, there are 22 topics and 92 subtopics in the curriculum [Table 2 and Figure 2, respectively]. While there is no special significance to the number of topics, the number of subtopics was chosen to facilitate planning and teaching of the core curriculum. As structured, the

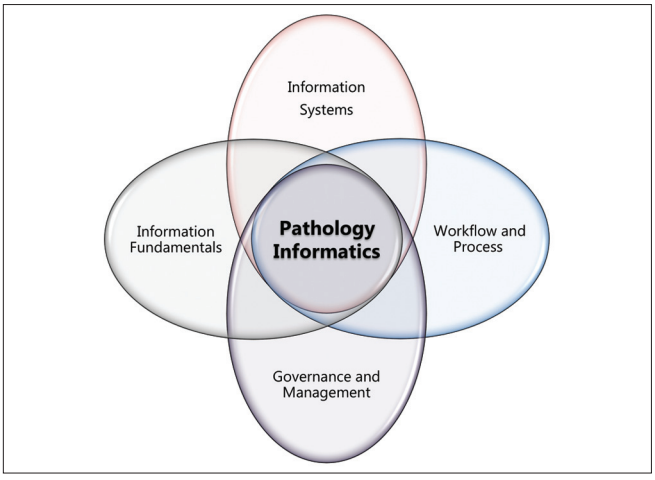


**Figure 1: The four primary divisions of study of the core curriculum for pathology informatics**

**Table 2: The four divisions of the Core Curriculum**

| Division | Topic |
|---|---|
| 1. Information fundamentals | 1.1. Healthcare informatics: History and concepts<br>1.2. Information architecture<br>1.3. Information quality<br>1.4. Information manipulation<br>1.5. Cognition and human computer interaction<br>1.6. Design principles<br>1.7. Special information domains |
| 2. Information systems | 2.1. Infrastructure fundamentals<br>2.2. Laboratory information systems (LIS)<br>2.3. Interfaces<br>2.4. System life-cycle<br>2.5. Health information systems<br>2.6. Imaging systems |
| 3. Workflow and process | 3.1. Process and quality improvement<br>3.2. Process management<br>3.3. Workflow analysis methods<br>3.4. Automation<br>3.5. Decision support in pathology<br>3.6. Special pathology process domains |
| 4. Governance and management | 4.1. Leadership<br>4.2. Management<br>4.3. Regulation |

The four divisions of the core curriculum are subdivided into topics (above), with each of the topics subdivided into Subtopics (see Tables 3-7)

core curriculum can be easily taught over either a one or two-year period, covering either two subtopics (one-year) or one subtopic (two-years) per week, with four weeks per year allotted for orientation, conferences, holidays, etc. Our program's preference to date is for the curriculum to be taught over a two-year period (assigning only one subtopic per week).

The content of the divisions of study and how each fits into the curriculum is described below.

## Information Fundamentals

The basis of any informatics training should, by necessity, include fundamental training about information itself. This is an area we found to be incompletely addressed in many informatics textbooks and we felt it was important to an informatics fellow's education. Information Fundamentals is comprised of seven topics and 26 subtopics [Table 3].

The first topic, Healthcare Informatics-History and Concepts, introduces the fellow to the history of healthcare informatics and nature of healthcare information. The second through fourth topics, Information Architecture, Information Quality, and Information Manipulation, explores how information is organized and structured, how it is accurately transmitted

**Table 3: Division 1. Information Fundamentals**

| Topic | Subtopic |
|---|---|
| 1.1. Healthcare informatics: History and concepts | 1.1.1. Medical and pathology informatics history and foundations<br>1.1.2. Fundamentals of healthcare information |
| 1.2. Information architecture | 1.2.1. Data architecture and modeling<br>1.2.2. Metadata in healthcare information<br>1.2.3. Database design and architecture<br>1.2.4. XML, the semantic web, and ontologies<br>1.2.5. Healthcare messaging models<br>1.2.6. Healthcare content vocabularies |
| 1.3. Information quality | 1.3.1. Information theory<br>1.3.2. Information quality principles<br>1.3.3. Healthcare information quality |
| 1.4. Information manipulation | 1.4.1. Data manipulation<br>1.4.2. Programming principles<br>1.4.3. Information retrieval<br>1.4.4. Data analysis principles<br>1.4.5. Decision support principles |
| 1.5. Cognition and human computer interaction | 1.5.1. Cognition<br>1.5.2. Human computer interaction<br>1.5.3. User interfaces<br>1.5.4. Information display |
| 1.6. Design principles | 1.6.1. Universal design principles<br>1.6.2. Software engineering and development |
| 1.7. Special information domains | 1.7.1. Image information principles<br>1.7.2. Molecular and genomic information principles (Bioinformatics)<br>1.7.3. Textual information principles<br>1.7.4. Cancer registries and public health information principles |

Core Curriculum Division 1, Information Fundamentals

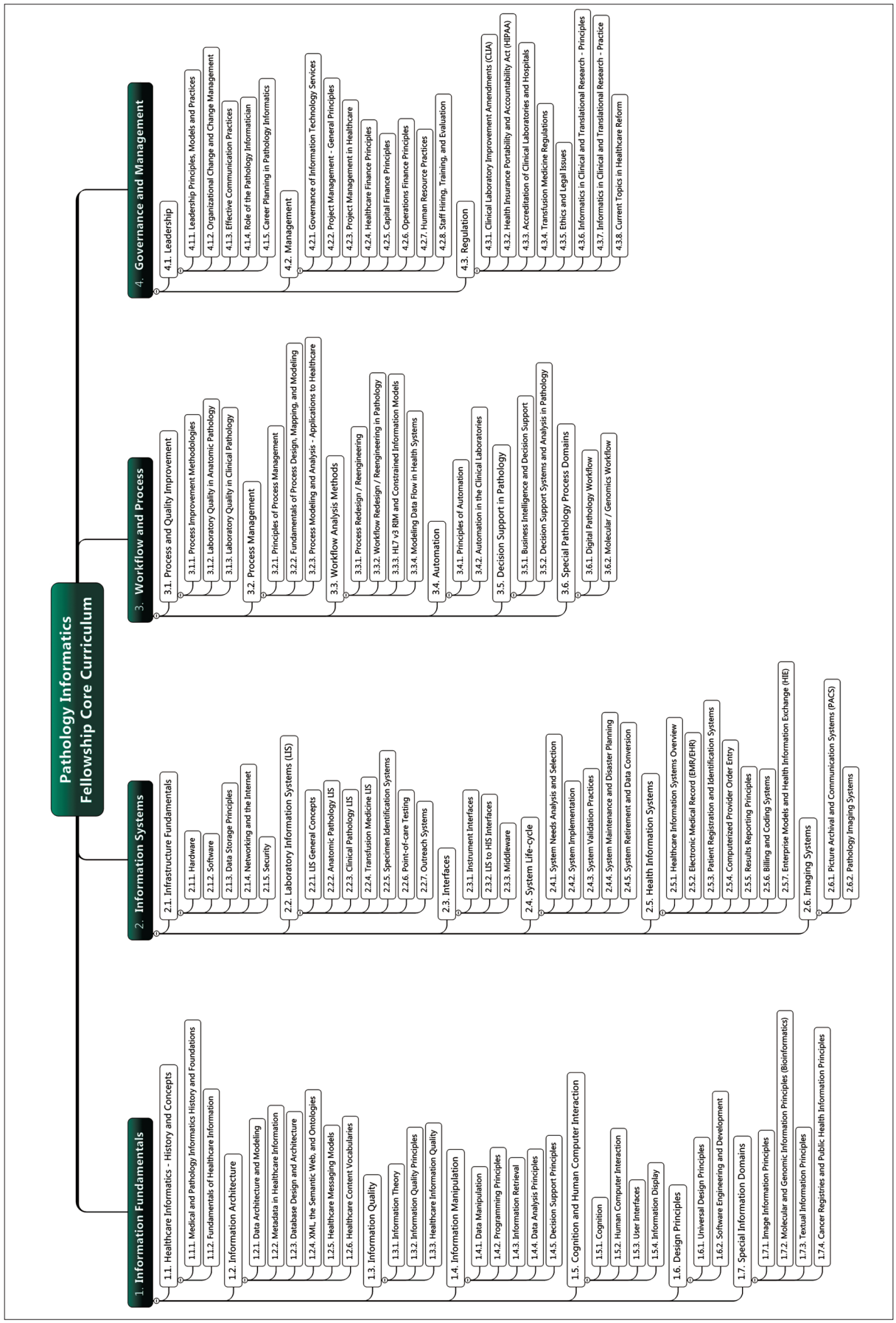


**Figure 2: The core curriculum for clinical fellowship training in pathology informatics**

**Table 4: Division 2. Information systems**

| Topic | Subtopic |
|---|---|
| 2.1. Infrastructure fundamentals | 2.1.1. Hardware<br>2.1.2. Software<br>2.1.3. Data storage principles<br>2.1.4. Networking and the internet<br>2.1.5. Security |
| 2.2. Laboratory information systems (LIS) | 2.2.1. LIS general concepts<br>2.2.2. Anatomic pathology LIS<br>2.2.3. Clinical pathology LIS<br>2.2.4. Transfusion medicine LIS<br>2.2.5. Specimen identification systems<br>2.2.6. Point-of-care testing (POCT)<br>2.2.7. Outreach systems |
| 2.3. Interfaces | 2.3.1. Instrument interfaces<br>2.3.2. LIS to HIS interfaces<br>2.3.3. Middleware |
| 2.4. System life-cycle | 2.4.1. System needs analysis and selection<br>2.4.2. System implementation<br>2.4.3. System validation practices<br>2.4.4. System maintenance and disaster planning<br>2.4.5. System retirement and data conversion |
| 2.5. Health information systems | 2.5.1. Healthcare information systems overview<br>2.5.2. Electronic medical record (EMR/EHR)<br>2.5.3. Patient registration and identification systems<br>2.5.4. Computerized provider order entry<br>2.5.5. Results reporting principles<br>2.5.6. Billing and coding systems<br>2.5.7. Enterprise models and health information exchange (HIE) |
| 2.6. Imaging systems | 2.6.1. Picture archival and communications systems (PACS)<br>2.6.2. Pathology imaging systems |

Core Curriculum Division 2, Information Systems

and maintained, and how it can be used, manipulated, and retrieved.

Cognition and Human Computer Interaction, the fifth topic, delves into how information is processed and interpreted by humans, including how to present information and the theory behind decision support. The sixth topic, Design Principles, takes both a theoretical approach to design in addition to a more practical approach, covering software engineering and development.

Finally, the fundamental principles underpinning information concepts relevant to specialized domains in Pathology Informatics today are taken into consideration in the seventh topic. These information domains include imaging, molecular pathology and genomics, textual information and natural language processing, and cancer registries and public health. Additional domains may be added in the future.

## Information Systems

Information systems form the backbone of every healthcare facility and organization today and thus play an extremely important role in a pathology informatics fellow's education. This division aims to familiarize fellows with the purpose, operations, and maintenance of clinical systems. Understandably, while the majority of pathology informatics programs primarily focus on the Laboratory Information System (LIS), we felt it important to not overemphasize the LIS within the core curriculum as this is one area usually covered extensively within operational rotations. More importantly, we wished to stress the relationship of the clinical laboratories and the LIS to other institutional/enterprise systems. Information Systems is comprised of six topics and 29 subtopics [Table 4].

The first topic, Infrastructure Fundamentals, covers those subtopics common to all information systems, including the hardware, software, data storage, networking, and security of these systems. The multiple components of Laboratory Information Systems make up the second topic, with the common interfaces necessary for proper operation of the LIS covered in the third topic.

**Table 5: Division 3. Workflow and process**

| Topic | Subtopic |
|---|---|
| 3.1. Process and quality improvement | 3.1.1. Process improvement methodologies<br>3.1.2. Software<br>3.1.3. Data storage principles |
| 3.2. Process management | 3.2.1. Principles of process management<br>3.2.2. Fundamentals of process design, mapping, and modeling<br>3.2.3. Process modeling and analysis |
| 3.3. Workflow analysis methods | 3.3.1. Process redesign / reengineering<br>3.3.2. Workflow redesign / reengineering in pathology<br>3.3.3. HL7 v3 RIM and constrained information models<br>3.3.4. Modeling data flow in health systems |
| 3.4. Automation | 3.4.1. Principles of automation<br>3.4.2. Automation in the clinical laboratories |
| 3.5. Decision support in pathology | 3.5.1. Business intelligence and decision support<br>3.5.2. Decision support systems and analysis in pathology |
| 3.6. Special pathology process domains | 3.6.1. Digital pathology workflow<br>3.6.2. Molecular / Genomics workflow |

Core Curriculum Division 3, Workflow and Process

**Table 6: Division 4. Governance and management**

| Topic | Subtopic |
|---|---|
| 4.1. Leadership | 4.1.1. Leadership principles, models, and practices<br>4.1.2. Organizational change and change management<br>4.1.3. Effective communication practices<br>4.1.4. Role of the pathology informatician<br>4.1.5. Career planning in pathology informatics |
| 4.2. Management | 4.2.1. Governance of information technology services<br>4.2.2. Project management – General principles<br>4.2.3. Project management in healthcare<br>4.2.4. Healthcare finance principles<br>4.2.5. Capital finance principles<br>4.2.6. Operations finance principles<br>4.2.7. Human resource practices<br>4.2.8. Staff hiring, training, and evaluation |
| 4.3. Regulation | 4.3.1. Clinical laboratory improvement amendments (CLIA)<br>4.3.2. Health insurance portability and accountability act (HIPAA)<br>4.3.3. Accreditation of clinical laboratories and hospitals<br>4.3.4. Transfusion medicine regulations<br>4.3.5. Ethics and legal issues<br>4.3.6. Informatics in clinical and translational research – Principles<br>4.3.7. Informatics in clinical and translational research – Practice<br>4.3.8. Current topics in healthcare reform |

Core Curriculum Division 4, Governance and Management

The fourth topic, System Life-cycle, is included in the curriculum as it is extremely important, yet underrepresented, within informatics texts; while system needs analysis and selection is commonly covered in other texts, the other four subtopics covering system implementation, validation, maintenance, disaster planning, retirement, and legacy data conversion are not. For example, PubMed searches for either of the general terms "information system data conversion" and "information system retirement" yield no results for the quoted phrases.

Non-LIS health information systems are addressed in the fifth topic. As this topic had the potential to be quite large, we primarily focused on these systems from the perspective of the pathologist, the pathology informatician, and the clinical laboratories. Imaging Systems is the sixth and final topic in this division and focuses on Picture and Archival Communication Systems (PACS) from the radiology perspective before diving

into the emerging area of digital pathology via Pathology Imaging Systems.

### Workflow and Process

Pathology informaticians routinely work with pathologists, clinical lab directors, and technical directors to improve the efficiency and effectiveness of diagnostic and laboratory workflow and processes. The aim of this division is to provide fellows with a solid background in workflow and process theory, principles, and practice, emphasizing its role in healthcare, pathology, and the laboratories. Workflow and Process is comprised of six topics and 16 subtopics [Table 5].

Process and Quality Improvement is the first topic and reviews the major process improvement methodologies (e.g. Lean, Six-sigma) in addition to reviewing the fundamental concepts surrounding how to measure quality in the pathology laboratories. The second and third topics review the methodology of process management and workflow analysis, with special attention to healthcare related data flows and information models. The fourth topic covers the principles of automation, including the use of automation in the clinical laboratories. Decision Support processes in Pathology is the fifth topic, encompassing business intelligence theory, decision support systems, and analysis. Finally, the sixth topic, Special Pathology Process Domains, takes into account trends in special pathology workflow. Digital pathology and molecular/genomics are two areas currently covered.

### Governance and Management

A large part of an informatics director's job and duties is administrative and managerial. For this reason, we included the division of Governance and Management within the curriculum, especially given its essential role for pathology informatics fellows' future careers. Governance and Management is comprised of three topics and 21 subtopics [Table 6].

The first topic, Leadership, covers the different aspects of leadership itself, in addition to principles necessary for effective communication and organizational change. The second topic, Management, incorporates the structure and management of projects and resources. Training for healthcare and departmental finance, including capital and operational budgets, is included here as pathology informaticians may have to advise departments concerning large capital and operational commitments. Further, as more departments create separate divisions of Pathology Informatics, both leadership and management skills will be an asset for new Directors of Pathology Informatics.

The third topic, Regulation, addresses important dimensions of informatics not usually encountered during pathology residency or clinical informatics training. Specific regulatory agencies (e.g. CLIA, AABB), the Health Insurance Portability and Accountability Act (HIPAA), and accreditation for the clinical laboratories (CAP inspections, Joint Commission) are covered, in addition to aspects of clinical and translational research (e.g. tissue banking, bio repositories, etc.) and current topics in healthcare reform (e.g. meaningful use).

### The Core Curriculum Reading List

The reading list for the core curriculum is presented in the accompanying Appendix. Selection of readings for the core curriculum began in June 2011 and has continued through the present. The curriculum presented in the Appendix is current through early March 2012. The Appendix, as presented, is partially annotated, with only some portions of the reading list containing explanations for specific topic or subtopic readings. There are a total of 570 sources cited in the reading list, of which 268 are primary (required) readings, 269 are suggested readings, and 33 are suggested tutorials (websites, web-based

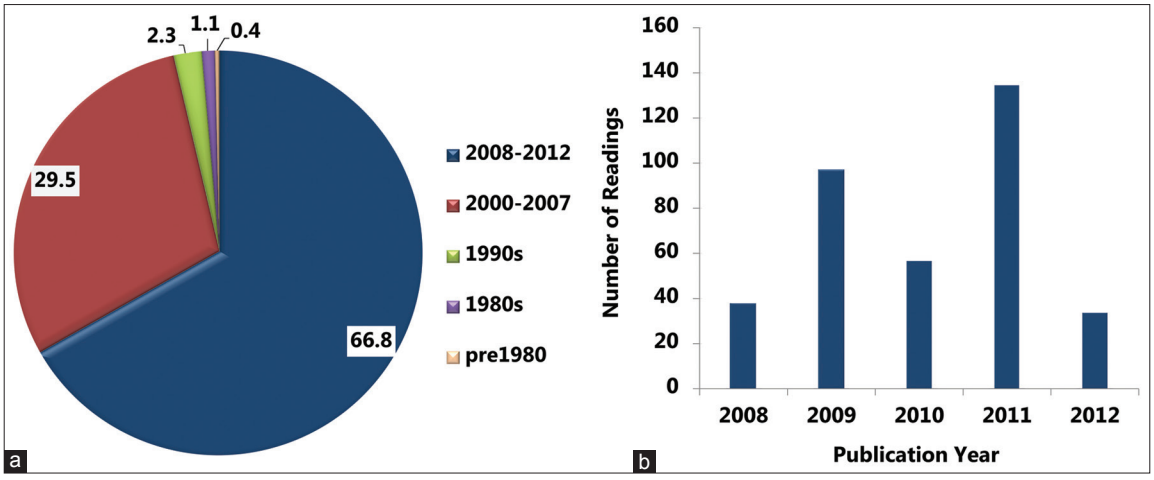


**Figure 3: Characteristics of the core curriculum reading list. (a) describes the percentage of readings (both primary and suggested) by publication date. (b) details the number of readings per publication year within the past five years**

tutorials, and online presentations).

The number of primary and suggested readings varies per subtopic, ranging from one to six readings for primary readings (average = 2.9, mode = 2) and one to seven readings for suggested readings (average = 2.9, mode = 2). As reading style and speed vary among fellows, data for the actual number of hours spent doing the readings, per subtopic, is not available; however, the reading list was created with the expectation of a range of 2-3 reading hours per subtopic (primary readings only).

Given the rapid nature of change within many of the topics of the curriculum, preference was given to more recently published sources [Figure 3a]. Of the 570 total sources, only a small handful of readings used (< 4%) were published prior to 2000, and less than one third of the readings were published between the years 2000-2007. Two thirds (66.8%) of the readings were published in the past five years (2008-2012), of which the majority of reading came from 2011, followed by 2009 [Figure 3b]. Maintaining the reading list for the curriculum will require significant organization and commitment going forward (discussed below).

## DISCUSSION

Developing the Core Curriculum for Clinical Fellowship Training in Pathology Informatics has been a large undertaking. Over the past three years there have been many insights, lessons learned, and potential implications discovered that surround the formal adoption of a comprehensive, core curriculum for Pathology Informatics.

### The Definition and Scope of Pathology Informatics

#### *Defining Pathology Informatics*

One of the reasons our initial didactic course did not succeed as well as we had hoped was directly related to the course's lack of a structured and defined curriculum. However, during our didactic course restructuring efforts a key issue that surfaced involved how to best define Pathology Informatics as a field - as we were attempting to design a curriculum that was to cover the scope and breadth of Pathology Informatics, we first needed to have a clear definition of what that scope was. Unfortunately, after reviewing the pathology informatics literature, it's fairly clear that if you asked ten different pathology informaticians to define their field, you would get back 10 different answers. In fact, this was exactly the case exhibited by our own informatics faculty members - when asked to define Pathology Informatics during an informatics-focused resident retreat; each one gave a different definition. What was interesting about this experience was that most definitions provided by the faculty were similar at the outset; it was only after the first sentence did they begin to diverge, usually with a bias towards their own specialty (Anatomic Pathology, Clinical Pathology, Molecular Pathology, etc.).

From this realization, the fellowship Program Director developed a simple and concise definition of Pathology Informatics:

Pathology Informatics is the study and management of information, information systems, and processes in Pathology.

We believe that the definition above, while short, sufficiently covers the current scope of Pathology Informatics without limiting it to the specifics of any subspecialty within Pathology. It is one that can be easily understood by all pathologists, clinicians, and technologists. Further, it allows for a large degree of flexibility in the future as pathology and healthcare changes in response to new methodologies, technologies, and initiatives.

The Core Curriculum presented in this paper [Figure 2, Tables 3-6] is a product of the above definition. The structure of the curriculum comes from the three primary components of the definition (information, information systems, and processes), with the governance and management of these components forming the fourth. The flexibility of the definition gives the curriculum its dynamic nature; any of the 22 topics or 92 subtopics in the curriculum can be changed as necessary to fit the needs of the training program and fellows without changing the intent of the curriculum itself.

#### *Pathology Informatics Has a Broad Scope*

A fundamental lesson learned from the first iteration of the didactic course was that we underestimated the breadth of material required to give our fellows a common, comprehensive knowledge base in Pathology Informatics. In short, Pathology Informatics has a very broad scope. This may seem to be an obvious statement to some; however, we feel it is one that needs saying as it has implications for both the curriculum and for the future of the field.

The broad scope of Pathology Informatics presented in the curriculum above is based in experience. Our rationale for selecting the topics and subtopics for the curriculum is based on looking at the tasks, scenarios, projects, and problems encountered on a day-to-day basis by any of our program's eleven Pathology Informatics faculty. This assessment not only provided us with the scope of our curriculum, it also led us to recognize two fundamental insights concerning Pathology Informatics as a whole.

The first insight is that Pathology Informatics is much too broad of a field for any one person to be an expert in all areas. Essentially, what this means is that one should expect pathology informatics to follow in the

footsteps of both Anatomic and Clinical Pathology, where subspecialization into discrete services has become the norm. In fact, this can already be seen in a small number of institutions today (including ours) that are able to support more than one Pathology Informatics faculty member - in these cases there are members of the faculty who specialize in AP Informatics, CP Informatics, Workflow and Process, Bioinformatics, Imaging, etc.

The second insight is that there is a considerable imbalance in the current Pathology Informatics literature. If we had designed the curriculum based solely on the representation of specific topics in this literature, many of the topics and subtopics would have barely registered as a blip on its radar. Instead, the vast majority of the curriculum would be comprised of the use of digital imaging in Anatomic Pathology, more specifically the use of telepathology, whole slide imaging (WSI), and image analysis.

As an example of this, we reviewed all of the articles published in the Journal of Pathology Informatics since its inception in May 2010 to March 2012 and found that 60% of the articles have digital imaging or image analysis as the primary focus of the article (data not shown). While this topic is certainly important, it is fairly safe to say that digital imaging is not what takes up 60% of most practicing pathology informaticians' time and efforts.

**Table 7: Application of the core curriculum to "Real-world" pathology informatics scenarios**

| Implementation of CPOE in a healthcare system | Whole slide imaging: Implementation in anatomic pathology for clinical use |
|---|---|
| Information fundamentals | Information fundamentals |
| 1.2.5. Healthcare messaging models | 1.2.1. Data architecture and modeling |
| 1.2.6. Healthcare content vocabularies | 1.2.2. Metadata in healthcare information |
| 1.4.5. Decision support principles | 1.2.5. Healthcare messaging models |
| 1.5.1. Cognition | 1.2.6. Healthcare content vocabularies |
| 1.5.3. User interfaces | 1.4.3. Information retrieval |
| 1.7.3 Textual information principles | 1.5.2. Human computer interaction |
| | 1.5.3. User interfaces |
| | 1.5.4. Information display |
| | 1.7.1. Image information principles |
| Information systems | Information systems |
| 2.2.2. Anatomic pathology LIS | 2.1.3. Data storage principles |
| 2.2.3. Clinical pathology LIS | 2.1.4. Networking and the internet |
| 2.2.4. Transfusion medicine LIS | 2.2.2. Anatomic pathology IIS |
| 2.2.5. Specimen identification systems | 2.3.1. Instrument interfaces |
| 2.3.2. LIS to HIS interfaces | 2.3.3. Middleware |
| 2.3.3. Middleware | 2.4.2. System implementation |
| 2.5.2. Electronic medical record (EMR/EHR) | 2.4.3. System validation practices |
| 2.5.4. Computerized provide order entry | 2.4.4. System maintenance and disaster planning |
| 2.5.6. Billing and coding systems | 2.6.1. Picture archival and communication systems (PACS) |
| | 2.6.2. Pathology imaging systems |
| Workflow and process | Workflow and process |
| 3.3.4. Modeling data flow in health systems | 3.1.2. Laboratory quality in anatomic pathology |
| 3.4.2. Automation in the clinical laboratories | 3.2.2. Fundamentals of process design/Mapping/Modeling |
| 3.5.1. Business intelligence and decision support | 3.3.2. Workflow redesign / Reengineering in pathology |
| 3.5.2. Decision support systems and analysis in pathology | 3.4.1. Principles of automation |
| | 3.4.2. Automation in the clinical laboratories |
| | 3.6.1. Digital pathology workflow |
| Governance and management | Governance and management |
| 4.1.2. Organizational change and change management | 4.1.2. Organizational change and change management |
| 4.1.3. Effective communication practices | 4.1.3. Effective communication practices |
| 4.2.1. Governance of information technology services | 4.2.1. Governance of information technology services |
| 4.2.3. Project management in healthcare | 4.2.3. Project management in healthcare |
| | 4.2.8. Staff hiring/Training/ and Evaluation |
| | 4.3.1. Clinical laboratory improvement amendments |
| | 4.3.2. Health insurance portability and accountability act |
| | 4.3.3. Accreditation of clinical laboratories and hospitals |

The table above demonstrate the various subtopics within the curriculum from which Pathology Informaticians must draw knowledge in order to effectively understand and successfully navigate real-world projects and scenarios, such as the implementation of CPOE within a healthcare system (right column) or the implementation of whole slide imaging for clinical use within Anatomic Pathology (left column)

Vastly underrepresented are detailed articles and books that discuss the nuts and bolts of pathology informatics, such as the design, implementation, maintenance, and operations of the LIS and its interactions and interfaces with other hospital systems, the application of workflow and process to both AP and CP laboratories, implementation and maintenance of CPOE from the perspective of the laboratories, data quality, etc. Unfortunately, both the lack of a clear definition and non-representative literature has contributed to a misunderstanding of informatics among most practicing pathologists, a problem we hope this curriculum helps to alleviate in the years ahead.

## Using the Core Curriculum within the Clinical Fellowship Training Program in Pathology Informatics

### *Translating the Core Curriculum to the Practice of Pathology Informatics*

One of the challenges in creating a curriculum is ensuring that the syllabus and course cover all of the topics necessary to achieve the educational goals. In this case our goals were two-fold: (1) to teach fellows the core knowledge set of pathology informatics in a reasonable time frame and with existing resources; and (2) to supplement the intense, hands on, individualized training that fellows receive in rotations and concentrations with a common educational experience across the breadth of the field. We believe we have made significant progress on those fronts, with a curriculum of four divisions, 22 topics, and 92 subtopics that includes a 570-source reading list (representing over 400 authors with both introductory and advanced reading for each subtopic) that is effectively presented by a program director in 92-hours of class time.

A possible criticism of the curriculum is that it does not appear to spend enough time on any specific real world topic to be useful. For example, a cursory examination of the curriculum would reveal a single subtopic dedicated to computerized provider order entry (CPOE) [Table 4, subtopic 2.5.4] and one could reasonably argue that a single session is not enough to fully understand the issues surrounding a CPOE implementation. The same could be said for one of the hotter topics in Pathology Informatics today, whole slide imaging, as this topic does not appear by name at all within the curriculum.

However, the curriculum was built in such a way that multiple topics and subtopics are relevant to most real world pathology informatics scenarios, even if they are not labeled as such. In Table 7, we have revised and reorganized the curriculum so as to show the multiple topics and subtopics from all four major divisions that are relevant to only to CPOE or WSI. Specifically, we can identify minimally 23 subtopics directly relevant to CPOE and 33 subtopics for WSI. Not only does this show the multiple relationships in pathology informatics, it also demonstrates the importance of fellows having a common, broad understanding of the field.

### *Implications of Having a Common Knowledge Base for the Field*

Without a common knowledge base, represented here by a core curriculum, it will remain difficult for fellowship programs to certify the existence of a common, core knowledge set, even among fellows that graduate from the same program. The lack of a common, certifiable knowledge set will limit the development of an otherwise promising field.

As an example, consider an institution wishing to hire a new hematopathologist. For this position, the members of the hiring committee both understand the scope of the field for the position and can reasonably estimate the skill sets, knowledge base, and competency a hematopathology fellowship trained, board-certified candidate will have.

Can the same be said for Pathology Informatics? Unfortunately, the answer is no. It can be argued that, unlike in the above hematopathology example, the majority of institutions and pathology departments are not experienced with the field of Pathology Informatics and cannot be expected to reasonably estimate the knowledge base and skill sets for a fellowship trained pathology informatician. Further, given that future board certification will most likely be pushed towards a more general, Clinical Informatics focus instead of offering a more specific Pathology Informatics version of the exam (at least initially), institutions will still not know what to expect of these new, "board-certified" informaticians. Without the adoption of a pathology specific core informatics curriculum within Pathology Informatics fellowship training programs, the expectations for pathology informaticians will remain loose and ill defined.

### *The Curriculum as an Educational Component of the Fellowship Program*

One of the issues with creating a curriculum of this scope revolves around how to keep it both comprehensive and dynamic over time. The task of creating the reading list itself was labor intensive, requiring many man-months to complete and we expect that updating and maintaining it will also require a significant amount of effort.

While time consuming, curating the reading list (researching, reviewing, and selecting the readings) proved itself an excellent educational activity, with feedback from the involved fellows being very positive. Further, an additional benefit of having fellows responsible for updating and maintaining the reading list was the exposure they received to the range of published literature and to the experts in the field. While we did not intentionally seek out specific readings by specific people, in the end we noticed that a majority of the acknowledged experts in Pathology Informatics, and

even some experts in Clinical Informatics, have been represented in the curriculum. Given the educational benefits, in future years the program will officially require the fellows to participate in the reading list curating process as part of their scholarly activities.

### Comparison to the AMIA Core Content for Clinical Informatics

In spring 2009, the American Medical Informatics Association (AMIA) published two white papers proposing the Program Requirements[40] and Core Content[41] for a new subspecialty of Clinical Informatics. In autumn 2011, the American Board of Medical Specialties officially recognized Clinical Informatics as a formal subspecialty,[42] with board-certification to occur sometime in the next few years.

Recently, a comparison between the proposed AMIA program requirements and the program requirements of our existing Pathology Informatics fellowship program has been published.[38] In short, our findings concluded that the current fellowship program could easily meet all of the substantive proposals outlined in the 2009 AMIA Program Requirements white paper.

In regards to the Core Content for Clinical Informatics proposed by the AMIA working group, a similar detailed, point-by-point comparison could not be performed at this time, given that the AMIA Core Content is, as published, more of a prospectus than a formal curriculum (to our knowledge it has not been implemented by a fellowship program and does not include a syllabus or reading list). On the surface, however, a couple of general points can be made regarding our current Core Curriculum for Pathology Informatics and AMIA's proposed Core Content for Clinical Informatics.

The major difference between the two curricula relates to the nature of the fields they are describing. Clinical Informatics, as defined by AMIA, is focused on "information and communication systems that enhance individual and population health outcomes, improve patient care, and strengthen the clinician-patient relationship."[41] Pathology Informatics, while also concerned with improving health outcomes and patient care, by the nature of the field must focus more on the clinical laboratories, including their information systems, processes, data flow, and regulation.

Interestingly, however, even though we did not use the 2009 AMIA white paper as a template for our curriculum, a cursory analysis shows an approximately 70% concordance between the Clinical Informatics Core Content and our Pathology Informatics Core Curriculum. In fact, three of the four high-level divisions (categories) are fairly similar, with the major difference lying in the emphasis on "Clinical Decision Making and Care Process Improvement" by the AMIA working group versus our emphasis of pathology "Workflow and Process" instead. Overall, we believe that understanding both the similarities and differences between these two fields will prove valuable as both clinical and pathology informaticians work together towards improving healthcare systems in the future.

## CONCLUSIONS

A clinical fellowship program has the responsibility of training its graduates to be competent in its field of study. However, to accomplish this, the fellowship program must have a clear vision of its field, including both the scope of the field and its associated knowledge base. Only when these criteria are met can a fellowship program ensure that its graduating fellows have learned the skill sets and competencies necessary for their future success.

We have described above our rationale, development process, and content for a Core Curriculum for Clinical Fellowship Training in Pathology Informatics. We feel that our core curriculum fulfills the needs of our fellows for a basic, common scope of Pathology Informatics knowledge while simultaneously enriching their rotations and clinical concentrations. We will continue to monitor both our fellows and the core curriculum over the coming years in order to gauge its effectiveness in training future pathology informaticians.

Finally, we believe that the curriculum presented here is a good step towards presenting the field of Pathology Informatics to the outside world, including Pathology itself and other healthcare specialties. Familiarity with the field, its core knowledge, and its expected skill sets will play a large role as pathology informaticians assume more important positions within healthcare systems in the years to come.

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